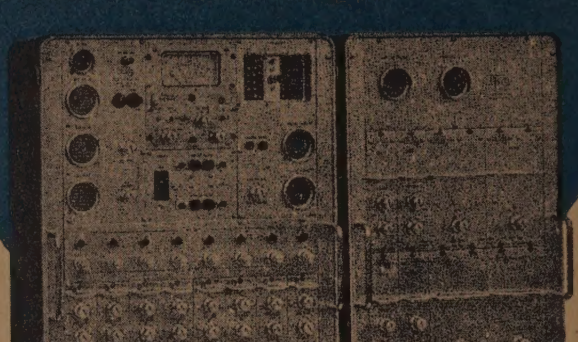
The Proceedings of the Geophysical Society of Tulsa

TABLE OF CONTENTS — PAGE 15

VOLUME 7

1959-1961

Take advantage of VELA UNIFORM equipment in your refraction or deep-reflection surveys



The GTR-200 system was originally developed and is now proven by use for the VELA UNIFORM crustal studies program being conducted by the U.S. Geological Survey. Transistorized, rugged, very-low-frequency refraction amplifiers included in the system provide a new dimension for seismic recording. Dual outputs are provided for both galvos and tape recorders to allow extended effective dynamic range recording. Provisions are made for using special geophones. System noise less than 0.2 microvolts combined with a 60 db. dynamic range make the GTR-200 system ideal for all types of advanced refraction recording studies.

TRANSISTORIZED VERY-LOW FREQUENCY REFRACTION AND DEEP-REFLECTION AMPLIFIER SYSTEM

GTR-200

CONDENSED SPECIFICATIONS

Input:	Transformer input, approximately 1200 ohms resistive above 2 cps.
Frequency Response:	Broad band: Within 3 db—1 to 300 cps.
Filters:	Lo-Cut: 18 db/oct—Out, 3½, 7, 14 cps.
	Hi-Cut: 18 and 36 db/oct—Out, 9, 13, 18, 26, 37, 100 cps.
Distortion:	Less than .5%. Dynamic range 60 db.
Noise:	Approximately .12 microvolts peak-to-peak 1 to 26 cps.
Outputs:	Galvo: Dual output, 0 and -15 db.
	Hi-Z Tape: Dual output, 0 and -30 db.
Power Requirements:	Total 8-channel system approximately .7 amp @ 24 VDC.

SIE DIVISION

DRESSER ELECTRONICS

10201 Westheimer, Zone 42 / P. O. Box 22187, Zone 27 / Houston, Texas

PHONE: SUnset 2-2000 CABLE: SIECO HOUSTON TWX: HO-118

Equipment backed by 16 years of world-leadership and world-wide service. Offices in Canada, Europe and Mexico—agents throughout the free world

apperception*

. . . is the *PLUS* quality which distinguishes a NATIONAL seismic exploration program. Let National Geophysical Company aid you in *your search for oil.*

*clear discernment by intelligent interpretation of existing findings in light of past experience.

NATIONAL GEOPHYSICAL COMPANY, INC. . . Dallas . . Houston

2345 W. Mockingbird Lane, Dallas 35 Texas, FLeetwood 2-2671

NATIONAL GEOPHYSICAL COMPANY OF CANADA, LTD . . . Calgary, Alberta, Canada

namco INTERNATIONAL INCORPORATED • P. O. BOX 35666, Dallas

THE GEOPHYSICAL SOCIETY OF TULSA

Founded 1947

Officers 1959-1960

President	T. S. Green
First Vice-President	James E. Hawkins
Second Vice-President	Kenneth S. Cressman
Secretary	Bert L. Bass
Treasurer	Robert B. Fisher

Officers 1960-1961

President	Ralph D. Lynn
First Vice-President	W. B. Brinnon
Second Vice-President	H. L. Mendenhall
Second Vice-President	J. A. Westphal
Secretary	Waynard B. Perry
Treasurer	W. M. Brooks

DISTRICT REPRESENTATIVES TO THE S.E.G.

1959-1960	1960-1961
W. H. Courtier	Craig Ferris
Paul L. Lyons	William M. Erdahl
Frank L. Searcy	James F. Johnson

REFRACTION COMMITTEE

James F. Johnson, Chairman

W. T. Born	James J. Roark
Karl Dyk	Ben F. Rummerfield
Henry B. Ferguson	Daniel Silverman
T. S. Green	Paul M. Tucker
James E. Hawkins	Kenneth H. Waters
Paul L. Lyons	Robert J. Watson

J. A. Westphal

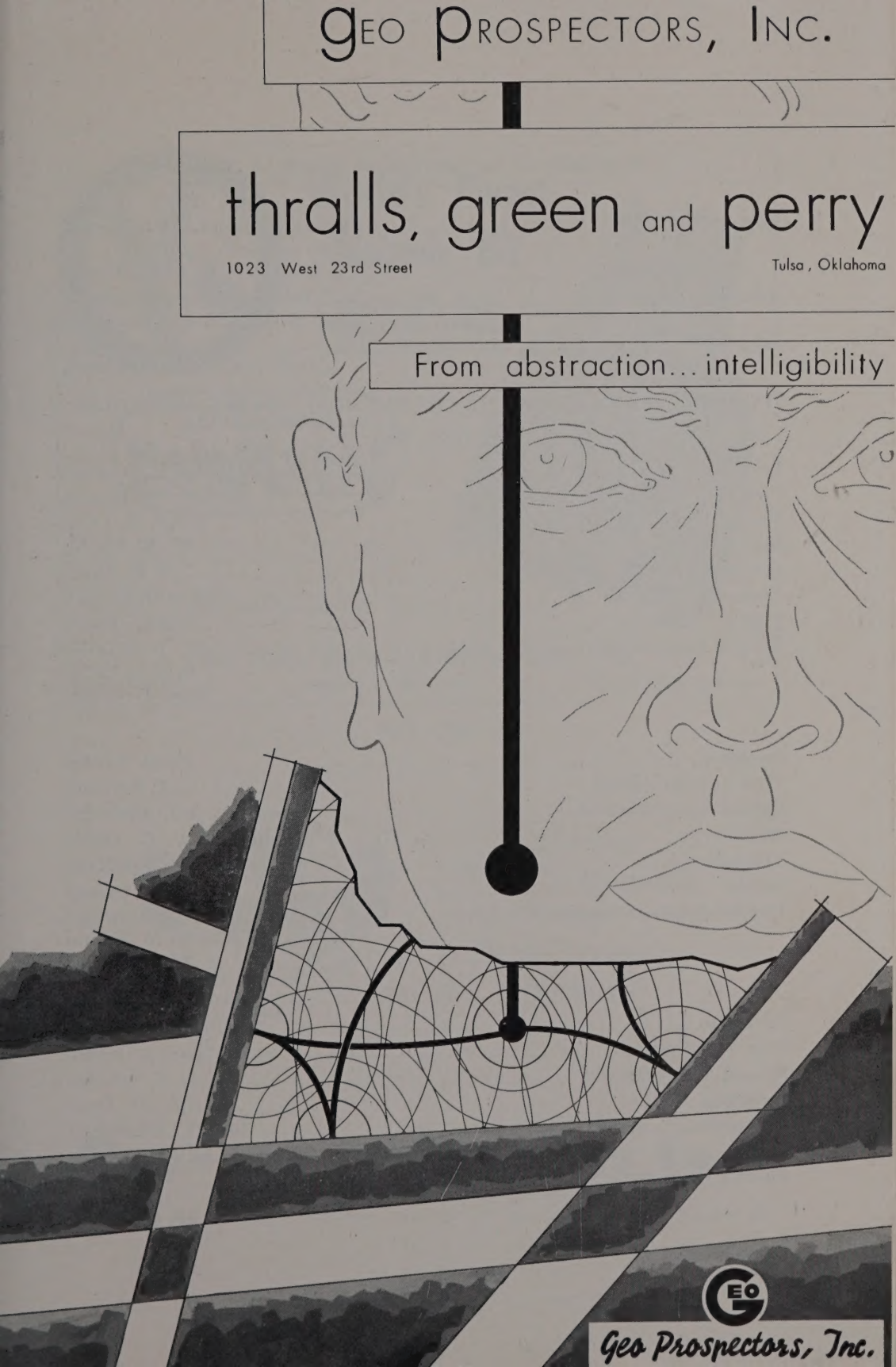
GEO PROSPECTORS, INC.

thralls, green and perry

1023 West 23rd Street

Tulsa, Oklahoma

From abstraction... intelligibility



GEO

Geo Prospectors, Inc.

Editor—1959-1960	Hughes M. Zenor (Transferred) James J. Roark
1960-1961	Paul M. Tucker
Advertising Agency	White Advertising Agency, 2010 S. Utica, Tulsa, Oklahoma
Sales Agency	Tulsa Book Shop, 116 E. 5th, Tulsa, Oklahoma

FORMER OFFICERS OF THE GEOPHYSICAL SOCIETY OF TULSA

1958 - 1959

President	James F. Johnson
First Vice-President	James E. Bondurant
Second Vice-President	Ralph D. Lynn
Secretary	W. W. Butler
Secretary (Acting April, May)	S. E. Giulio
Treasurer	Edward Weltsch
Editor	James J. Roark
District Representatives to the S.E.G.	W. T. Courtier Paul L. Lyons Frank L. Searcy

1957 - 1958

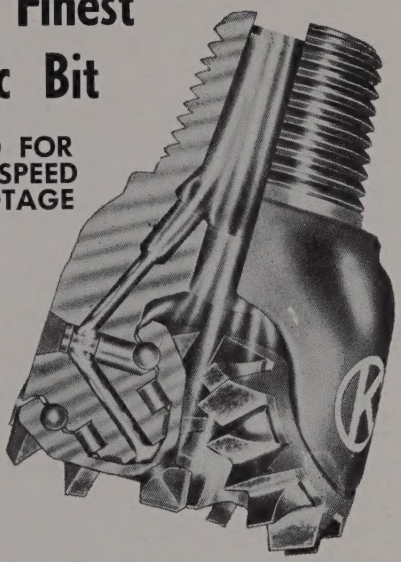
President	Frank Searcy
First Vice-President	T. S. Green
Second Vice-President	Frank R. Kittredge
Secretary	S. E. Giulio
Treasurer	Perry M. McNally
Editor	R. L. Frossard
District Representatives to the S.E.G.	John M. Crawford William M. Erdahl Paul J. Lyons

1956 - 1957

President	William M. Erdahl
First Vice-President	John J. Rupnik
Second Vice-President	James F. Johnson
Secretary	Ralph D. Lynn
Treasurer	John E. Bondurant
Editor	V. L. Jones
District Representatives to the S.E.G.	W. T. Born L. Y. Faust H. M. Thralls

World's Finest Seismic Bit

DESIGNED FOR GREATER SPEED AND FOOTAGE



Williams HoleMaker ROCK BITS

K and HoleMaker Bits, 2 1/16" through 7 7/8", are made of highest nickel alloy steel forgings and are heat treated in newest automatic furnaces for guaranteed quality, consistency and wear resistance in roughest drilling conditions. "Every Bit the Best."

OIL TOOL MANUFACTURING CO., INC.

P. O. BOX 24 TONKAWA, OKLAHOMA PHONES 143 and 144

GSI

Seismic, Gravity-Magnetic and Data Processing Services

GEOPHYSICAL SERVICE INC.

A TEXAS INSTRUMENTS COMPANY

900 EXCHANGE BANK BLDG • DALLAS 35, TEXAS

1955 - 1956

President	John M. Crawford
First Vice-President	Stanley W. Wilcox
Second Vice-President	Wm. M. Erdahl
Secretary	John J. Rupnik
Treasurer	John E. Bondurant
Editor	E. V. McCollum
District Representatives to the S.E.G.	W. T. Born
	L. Y. Faust
	H. M. Thralls

1954 - 1955

President	L. Y. Faust
First Vice-President	Frank Searcy
Second Vice-President	Ben F. Rummerfield
Secretary	T. S. Green
Treasurer	George C. Walton
Editor	Charles W. Oliphant
District Representatives to the S.E.G.	A. B. Bryan
	W. T. Born
	Norman H. Ricker

1953 - 1954

President	Norman H. Ricker
First Vice-President	John M. Crawford
Second Vice-President	R. W. Mossman
Secretary	Tom F. Southgate
Treasurer	David B. Weichert
Editor	Robert J. Watson
District Representatives to the S.E.G.	E. V. McCollum
	R. G. Piety
	R. H. Tucker

1952 - 1953

President	Paul J. Lyons
First Vice-President	L. Y. Faust
Second Vice-President	W. B. Agocs
Secretary	Dallas R. Davis
Treasurer	Francis H. Cady
District Representatives to the S.E.G.	E. V. McCollum
	R. G. Piety
	R. H. Tucker

Do you think gravity will work in this area?

This is probably the most common question asked people in our specialty. The answer is yes.

The nice thing about gravity is that it always works. We are measuring an inherent phenomena of nature which is universally present. We need send out no energy to get our signals —rather we measure the signals provided by nature herself. Specific gravity is a property that is common to all rocks. Thus, we need make no qualifications in answering this question in the affirmative. But obviously a literal answer to the question is not satisfactory to our oil-hunting inquirer.

The question really being asked is: To what extent does gravity give us information about those top few miles of the earth's crust, which are of particular interest to the oil-hunter?

Again we answer in the affirmative but not with one word. The answer lies only in experience gathered through study of gravity maps and their correlation with known subsurface information. From our experience so far, we believe the following statements are reliable:

(1) If salt domes are present they will be easily recognized whether shallow or relatively deep-seated.

(2) In other areas where salt is not present in sufficient quantities to make domes, there is almost invariably an increase in density with depth which is sufficient to cause measurable maximum gravity anomalies over the larger structural uplifts.

(3) There are usually deep-seated trends associated with the basement complex which influence the superimposed structural trends. In areas of most low relief these trends may be the most important data on the gravity map.

If proper use then is made of the data, allowing due respect to Newton's Law, error of observation, and experience in similar geologic provinces, we feel that the gravity information will always be worth many times its cost.

Thomas J. Bevan

910 South Boston Tulsa, Oklahoma

1951 - 1952

President	R. W. Gemmer
First Vice-President	Craig Ferris
Second Vice-President	J. E. Hawkins
Secretary	J. C. Rollins
Treasurer	Clare N. Hurry
District Representatives to the S.E.G.	John M. Crawford
	R. H. Tucker
	R. G. Piety

1950 - 1951

President	H. M. Thralls
First Vice-President	Paul L. Lyons
Second Vice-President	Neal Clayton
Secretary	Robert C. Kendall
Treasurer	Wm. M. Erdahl
District Representative to the S.E.G.	John M. Crawford

1949 - 1950

President	W. T. Born
First Vice-President	E. M. McNatt
Second Vice-President	N. J. Christie
Secretary-Treasurer	N. R. Sparks
District Representatives to the S.E.G.	J. P. Garner
	J. E. Hawkins

1948 - 1949

President	A. B. Bryan
First Vice-President	Francis F. Campbell
Second Vice-President	V. L. Jones
Secretary-Treasurer	Glen D. Lambert
District Representatives to the S.E.G.	W. H. Courtier
	J. P. Garner

1947 - 1948

President	R. Clare Coffin
First Vice-President	A. B. Bryan
Second Vice-President	H. M. Thralls
Secretary-Treasurer	Francis F. Campbell
Members of the Executive Committee	E. J. Handley
	J. A. Sharpe

1947

President	R. Clare Coffin
Vice-President	E. J. Handley
Secretary	Colin C. Campbell

Western Conducts More Marine Seismic Surveys Than All Other Contractors Combined!

Every year since 1954, Western Geophysical Company boats have done well over half of ALL contract offshore seismic explorations in the world.

This record reflects the considered judgment of many of the most respected people in the petroleum industry on the competence of Western men, techniques and instrumentation. When you consider your next geophysical survey, let us tell you more about the Western services that have earned and held such confidence.

Additionally,
Western's land seismic parties
and gravity crews
are at work on four continents.

Western
GEOPHYSICAL COMPANY
A SUBSIDIARY OF LITTON INDUSTRIES

Principal Office: 933 NORTH LA BREA AVENUE, LOS ANGELES 38, CALIFORNIA

AFFILIATE AND REGIONAL OFFICES THROUGHOUT THE WORLD

ADVERTISERS INDEX

	Page
Thomas J. Bevan	7
Continental Geophysical Co.	11
Dresser Electronics	Inside Front Cover
Electrodynamic Instrument Corp.	18
General Geophysical Co.	12
Geophysical Service, Inc.	5
Herb V. Hawthorne, Inc.	16
Indel Supply, Inc.	20
E. V. McCollum and Co.	24
Mayhew Supply Co., Inc.	135
Mid-Continent Geophysical Co.	150
National Geophysical Co.	1
Oil Tool Mfg.	5
Petty Geophysical Co.	14
Republic Exploration Co.	11
Schlumberger Well Surveying Corp.	22
Seismic Engineering	Back Cover
Seismograph Service Corp.	Inside Back Cover
Thralls, Green and Perry	3
Western Geophysical Co.	9

Continental Geophysical Company

REFLECTION & REFRACTION SEISMOGRAPH SURVEYS

Long and Short Term Crews

Home Office
1409 Continental Life Bldg.
Fort Worth, Texas
A. E. "Sandy" McKAY

Division Offices

Midland, Texas ..... C. N. PAGE, W. A. SEAL, JR.
Denver, Colo. ..... C. J. LOMAX
Oklahoma City, Okla. ..... L. E. TABOR

Short Term Crews Located in
Permian Basin, Rocky Mountains and Mid-Continent

Foreign Affiliate
NAMCO, International, Inc.
Box 35666, Dallas 35, Texas

A Short Lesson In:

Taking the "WILD" Out of "WILDCAT"

The search for a new oil pool, like hunting the "big game" cat is difficult under the best conditions. The successful oil explorer, like the successful "cat" hunter, takes advantage of every tool, plans every step to give himself the greatest advantage.

Republic field crews have an enviable record for success in the hunt for "wildcats," utilizing the most modern of "tools"—for recording, interpreting and analyzing.

Republic crews and equipment are chosen to furnish oil men with improved geophysical data required for successful exploration.

REPUBLIC EXPLORATION COMPANY

TULSA, OKLAHOMA — MIDLAND, TEXAS

REASON: *General Geophysical develops and produces its own custom-built instruments*

The ruggedness and reliability of the instruments and equipment used in General Geophysical's work mean better, faster service with less chance of error or of costly delay. Example—the General-built GEOPAC system that is famed for geophysical plotting and computing. Now, as shown above, General crews have portable GEOPAC units which provide fully corrected seismic records in the field.

General's extensive laboratory facilities offer you an important flexibility—equipment and instruments can be quickly custom designed and manufactured to fit the special needs of a job, to fit a special area and to fit your special requirements.

Find out for yourself the reasons behind General's reputation for leadership in geophysical instrumentation. Call General today . . .

General
GEOPHYSICAL COMPANY
Houston Club Building • Houston, Texas

Paris, France
Edmonton, Alberta
Nassau, Bahamas
Tripoli, Libya

When your contract is with General, the percentage for successful exploration is in your favor!

THE PROCEEDINGS OF THE GEOPHYSICAL SOCIETY OF TULSA

VOLUME 7, 1959-1961

James J. Roark, Editor 1959-1960
Paul M. Tucker, Editor 1960-1961
Robert J. Watson, Assoc. Ed. 1960-1961

For information on the Petty Stacking technique write to

Petty

GEOPHYSICAL ENGINEERING CO. TRANSIT TOWER SAN ANTONIO CApitol 6-1393

Petty's patented* horizontal stacking technique verifies each subsurface point with multiple ray paths. Since only the reflection point is common to all, noise is greatly reduced and maximum record clarity is assured.

*U. S. Patent No. 2,732,906

TABLE OF CONTENTS

Page

Advertiser's Index 10

Officers of the Society 2

Former Officers of the Society 4

Editor's Foreword 19

In Recognition 21

Earth Crust Measurements by Seismograph in Oklahoma — A Preliminary Report, *Paul M. Tucker, J. A. Westphal* 25

Earth Crust Measurements by Seismograph in Oklahoma — An Interim Report, Written by *James J. Roark*, Presented by *Ralph D. Lynn* 34

Dr. C. Hewitt Dix Comments 41

Features of a Device for Seismic Depth Soundings and Results of its Testing, *G. I. Aksenovich, E. I. Gal'perin* and *M. A. Zaionchkovskii* 45

An Experimental Application of the Seismic Depth Sounding Method to the Investigation of the Structure of the Earth's Crust in Parts of Western Turkmenia, *I. P. Kosminskaya* and *Yu V. Tulina* 53

Abstracts of Selected Soviet Papers on Earth Crust Measurements 71

Geophysical Society of Tulsa — Titles and Abstracts of Papers and Lectures 75

Title and Abstracts of Papers and Lectures Given Before Other Local Geophysical Societies ..... 79 - 124

A. Ark-La-Tex Geophysical Society 79

B. Asociacion Venezuela de Geofisica 81

C. Canadian Society of Exploration Geophysicists 82

D. Casper Geophysical Society 86

E. Coastal Bend Geophysical Society 89

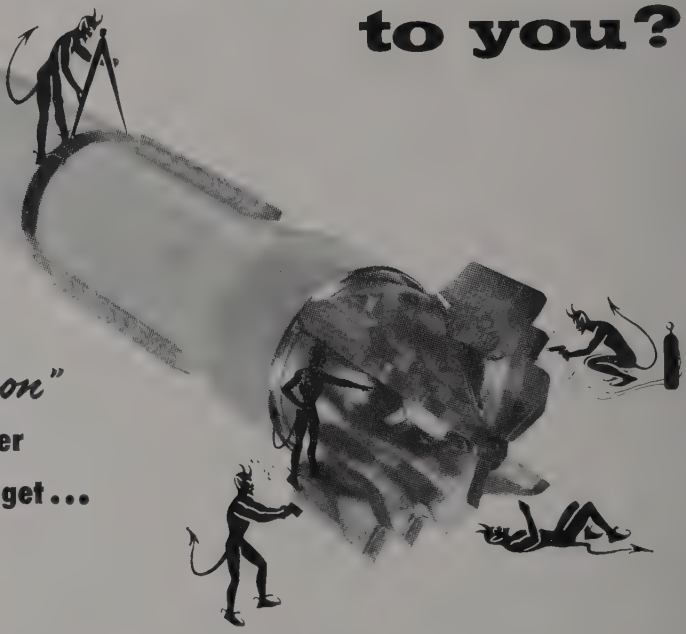
F. Cochabamba Geophysical Society 92

G. Dallas Geophysical Society 92

H. Denver Geophysical Society 96

K. Fort Worth Geophysical Society 98

Do all bits look alike to you?



Here's Why "Blue Demon" Bits Are Better For Your Budget...

"Blue Demon" Bits . . . the original replaceable blade bits developed to cut cost-per-foot in shot hole drilling . . . continue to pace bit progress as drilling conditions change.

The addition of cuttings deflectors to the face of Hawthorne's patented replaceable blades . . . to substantially reduce plugging between formation layers . . . gives the driller considerable versatility with drilling weights . . . which in turn results in faster hole . . .

Plus the 4-Blade feature developed for faster penetration in harder formations . . . with more cutting surface on bottom to keep the bit from walking . . . providing a straighter hole to load, and less strain on your drill . . .

Plus the highest quality of materials and craftsmanship in every Hawthorne "Blue Demon" product

Plus ample stocks of popular shot hole sizes maintained in every active exploration area . . .

. . . are reasons why more shot hole drillers use "Blue Demons" than all other drag-type bits combined. Try a set on your next hard-rock location.

WRITE FOR ILLUSTRATED CATALOG

HERB J. HAWTHORNE INC.

Cable Address: HAWBIT • P. O. Box 7366 • Houston 8, Texas

U.S. Patent Nos
2,615,684
2,666,622
2,695,158
2,783,973
2,831,657
2,859,942
2,890,020
2,894,726

298

TABLE OF CONTENTS

(*Continued*)

L. Four Corners Geophysical Society 100
M. Geophysical Society of Edmonton 102
N. Geophysical Society of Houston 104
O. Geophysical Society of Oklahoma City 105
P. Geophysical Society of South Texas 107
Q. Jackson Geophysical Society 107
R. Montana Geophysical Society 109
S. New Mexico Geophysical Society 110
T. Pacific Coast Sections S. E. G. 112
U. Permian Basin Geophysical Society 116
V. Regina Geophysical Society 117
W. Southeastern Geophysical Society 119
X. Southwest Louisiana Geophysical Society 121
Y. Utah Geophysical Society 123

Constitution and By-Laws 125
Candid Photos of the 1961 Picnic 131
Memorial – Maurice Hudiburg Wallace 133
– James Louis Catt 134
Membership Roll 136

Transcorder in operation at Canadian Magnetic Reduction, Calgary.

TRANSCORDER BUILDS NEW CANADIAN DATA-TRANSCRIBING SERVICE

Canadian Magnetic Reduction (Alberta) Limited, Calgary, has used EIC's Transcorder to offer its clients a new service based on transcribing seismic data from paper records onto magnetic tape. Since the Calgary firm installed its Transcorder early in 1961, customer demand has kept it busy constantly.

"Our clients have been pleased with the fidelity and usefulness of tape-recorded data transcribed from their paper records by our Transcorder," said Mr. Peter J. Savage, general manager of Canadian Magnetic Reduction.

"The need for this new instrument and the quality of the work it produces are shown by the fact that we have kept our Transcorder working two shifts daily for months."

The Transcorder transcribes seismic data onto any standard geophysical tape from paper records or from other AM tapes in common use.

Magnetic tapes produced by the Transcorder can be processed by playback systems that permit mixing, selective filtering, correcting for moveout, weathering, and elevation, and presentation in cross-section form with any type of display selected by the interpreter.

Call or wire EIC for detailed specifications on the Transcorder.

ELECTRODYNAMIC INSTRUMENT CORPORATION

Subsidiary of Reed Roller Bit Company

JA 6-3761 • 1841 Old Spanish Trail • Houston 25, Texas

Editors Foreword

This issue of the Proceedings of the Geophysical Society of Tulsa is for the two year period 1959-1961. The two years were combined inasmuch as the society's activities were centered mainly on one subject, "Earth Crust Measurements."

The activities and results of the work of our Refraction Committee on measurements of the earth's crust were given as talks at the Midwest Regional Meeting of the S.E.G. at Shreveport in April, 1960, and at the International S.E.G. Meeting in Galveston in November, 1960. Those talks are herewith recorded. We have also included Soviet papers and abstracts on their Earth Crust Measurements with the seismograph. Their work is not readily available and is included for completeness and comparison.

The publication of other geophysical societies programs is continued. This is the only such collective record, and we presume it serves a useful purpose for the other societies and individuals.

James J. Roark, Editor 1959-60
Paul M. Tucker, Editor 1960-61
Robert J. Watson, Associate Editor 1961

5 Stores to Serve You Best!

DRILLING – ELECTRONIC
SEISMIC RECORDING
MAGNETIC TAPE
SEIS-TAPE®
INDUSTRIAL SUPPLIES

If it's Used in Oil Exploration Call

INDEL SUPPLY, INC.

6749 E. 12TH ST.
TE 5-9568
TULSA, OKLAHOMA

2016 FARRINGTON ST.
RI 8-6688
DALLAS, TEXAS

2137 RICHMOND AVE.
JA 6-4185
HOUSTON, TEXAS

315 WESTSIDE DRIVE
322-9819
WICHITA FALLS, TEXAS

1507 W. 5TH STREET
HI 5-4801
PECOS, TEXAS

IN RECOGNITION

(The members of the G. S. T. were asked to fill out and return to the editor a form listing talks given, offices held or honors received during the past two years. Replies were received from the following members—Editor)

Austin, A. C., listed in "Leaders in American Science," Vol. IV, 1960-61.

Bennett, A. D., Talk given at SEG International Meeting, Galveston, Tex., November 7, 1960, Subject: "Study of Multiple Reflection Using a One-Dimensional Seismic Model."

Bevin, Thomas J., Talk given to Roswell Geophysical Society, Roswell, N. Mex. 5-9-61, Subject: "Least Squares approach to Residual Analysis of Gravity Data."

Bike, Peter B., Talks given to Dallas, Houston, Midland, Tulsa, Ft. Worth and Oklahoma City Geophysical Societies, Subject: "The Use of Geophysics in the Development Department."

Born, W. T., Talks: to Canadian Society of Exploration Geophysicists, Calgary, Alberta, Feb. 27, 1961, Subject: "Limitations of Geophysical Tools." Honor received: Honorary Membership in S.E.G., Los Angeles, Nov. 1959.

Brown, Graydon L., Talk given to Institute of Radio Engineers-Tulsa Section, Tulsa, Okla., April 20, 1961, Subject: "An Electronic Multichannel Analog Correlator."

Von Croy, Stefan, Honor received: SEG Silver certificate, Tulsa, Dec. 1959.

Crumrine, K. C., Honor received: American Petroleum Institute Subcommittee on Recording of Logging Signals for Data Processing.

Frost, Noel, Talk given to Southwest Louisiana Geophysical Society, Lafayette, La., May 6, 1960, Subject: "Synthetic Seismic Reflection Studies" by Breck, Schoellhorn & Frost.

Garten Jr., Roy E., Office held, Member of: Electronics and Electrical Advisory Committee, Oklahoma State Tech, Okmulgee, Okla.

Gillig, Fred, Office held: Co-chairman of Geological-Geophysical Directory, Tulsa, 1960-61.

Giulio, S. E., Office held: Membership Committee of SEG, Galveston, 1959-60.

Goupillaud, Pierre L., Talk given to SEG Convention, Galveston, November 1960, Subject: "Considerations Concerning the Use of the Continuous Velocity Log.," Office held:

Member of the Review Committee of SEG, 1960-61.

Gilmour, Andrew, Offices held:

Sec'y Treasurer SEG, National
Vice-President SEG, National 1948-49
President SEG, National 1949-50

Hammond, J. R., Talks given on subject: "Ghost Elimination from Reflection Records" to all of the following:

Ark-La-Tex Geophysical Society	Oct. 1958
New Mexico Geophysical Society	Nov. 1958
Geophysical Society of South Texas	Feb. 1959
Permian Basin Geophysical Society	Mar. 1959
Geophysical Society of Houston	Mar. 1959
Geophysical Society of Tulsa	Apr. 1959

Everything depends on this man.

From the time he rolls up to your location behind the familiar field unit, the success of your operation . . . and Schlumberger's too . . . is in his hands.

But look what he has done before he got there!

The typical Schlumberger field supervisor is a graduate engineer.
He has received extensive training at Schlumberger schools in the design, function, operation, maintenance, and field interpretation of more than 30 specific down-the-hole services.

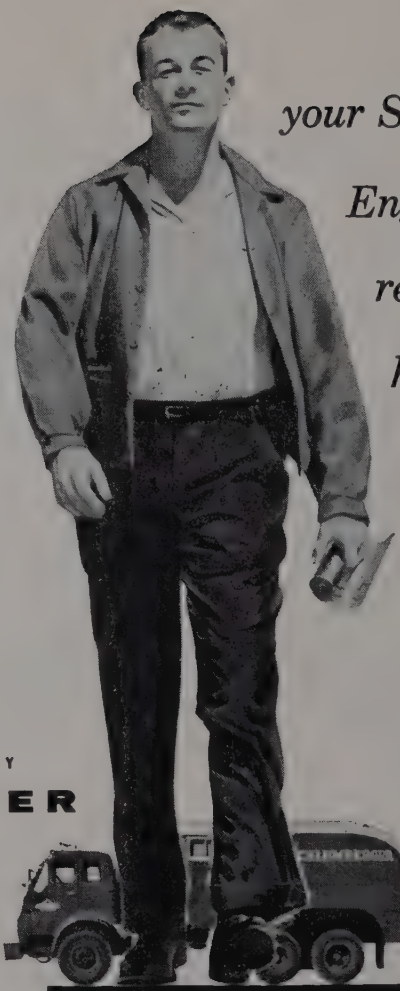
It's a man-sized, 24-hour-a-day job.
But you can be sure that he knows his business from the ground down . . . because Schlumberger devotes as much attention to engineer selection and training as to the development of new techniques.

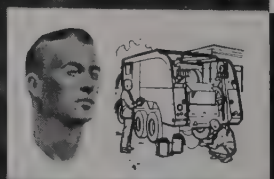
You might remember this the next time he walks up.
His credentials and capabilities are certified by success.

THE EYES OF THE OIL INDUSTRY

SCHLUMBERGER

your Schlumberger Engineer really knows his business





from the ground down

Hawkins, J. E., Offices held:

First Vice-President, GST, 1959-60

President GST, 1961-1962

Honors: Committee member on "Committee for Cooperation with Governmental Agencies in Connection with Project VELA.

Hurry, C. N., Office held: SEG Committee on Geophysical Activity, 1959-1961.

Jacobsen, Jr., Peter, Talks given:
To: Tercer Congreso Geologico Venezolano, Venezuela, Nov. 1959, Subject: Interpretacion de Datos Aeromagneticos en Los Llanos Occidentales de Venezuela.
To: Sociedad Venezolana de Geofisica, Caracas, Venezuela, March, 1960, Subject: An Evaluation of Basement Depth Determinations from Airborne Magnetometer Data.
To: Thirtieth Annual Meeting of SEG, Galveston, Tex. Nov. 1960, Subject: An Evaluation of Basement Depth Determinations from Airborne Magnetometer Data.
Offices held: Secretary-Treasurer, Sociedad Venezolana de Geologia, Mineria y Petroleo, Caracas, Ven., 1960.

Johnson, James F., Talk given at 30th Annual Meeting of SEG, Galveston, Nov. 1960, Subject: "Oil Exploration From the Research Standpoint."

Jones, V. L., Talk given at SEG Local Section, (Tulsa), March 1960, Subject: "Total Magnetic Field Survey of the Owasso Dome."

Kirby, Robert A., Talk given to Asociacion Venezolana de Geofisica, Caracas, Venezuela, August, 1959, Subject: Magnetic Tape Field Recording Systems."

Manhart, T. A., Honor received: Silver Anniversary Certificate at the 14th Annual Midwestern Exploration Meeting in Okla. City, Okla., April, 1961.

McCollum, E. V., Offices held:

President, SEG, 1958-59

Past-President, 1959-60

Oksa, Donald R., Talk Given: At 29th Annual International Meeting of SEG, Los Angeles, Calif., Nov. 1959, Subject: "Resolution and Curved Path Computation of Steep Dip Using an Electronic Computer."

Pohly, Richard A., Talk given to Tulsa Geological Society, Tulsa, Nov. 1960, Subject: "Gravity Surveys for Reefs and Fracture Trends."
Talk given to: Michigan Geological Society, Flint, Michigan, April, 1961, Subject: "Gravity Profile across Scipio Field."

Quigley, M. Darwin, Offices held:
President, I.A.P.G., Salt Lake City, 1951.
State Representative, R.M.S. of AAPG, Salt Lake City, 1957-58.

Searcy, Frank, Office held: 1st Vice President, SEG., Nov. 1959 - Nov. 1960.

Tucker, Paul M., Talk Given: Regional SEG at Shreveport, April 1960.
Subject: "Earth Crust Measurement by the Seismograph in Okla."
Talk given: Ark-La-Tex Geophysical Society, Shreveport, Feb. 1961.
Subject: "Earth Crust Measurement by the Seismograph in Okla."

Watson, R. J., Office held: Technical Program Committee, SEG Annual Meeting—Denver 1961.

Milligal hits a new high!

Everyone has their highs and lows, but Milligal cuts the cost of finding structures suitable for exploration.

Gravity surveys

based on practical application of the latest proven scientific methods, you can benefit from our broad experience and acquaintance with oil provinces throughout the world.

Call, wire or write for prompt, accurate geophysical surveys.

E. V. McCOLLUM & CO.

WE WEIGH THE EARTH

E. V. McCOLLUM — CRAIG FERRIS

515 Thompson Bldg. — Ph. LUther 2-3149

TULSA, OKLAHOMA

Foreign Affiliate: namco INTERNATIONAL

EARTH CRUST MEASUREMENTS BY SEISMOGRAPH IN OKLAHOMA – A PRELIMINARY REPORT

Geophysical Society of Tulsa

Given at the Regional S.E.G. Meeting in Shreveport, April, 1960

by

Paul M. Tucker

ABSTRACT

Stimulated by the 81 mile long refraction profile shot by Canadian Geophysicists in 1958, a refraction committee was formed within the Geophysical Society of Tulsa to promote a similar effort. The immediate objective was the planning of refraction profiles across the Ouachita Mountains of Oklahoma or similar nearby areas. Before such an undertaking was attempted, it was first decided to make some preliminary recordings locally to test the methods and procedures.

On November 10, 1959, a recording was made with a 1210′ spread at 26 miles from a routine quarry blast. A second recording was made five miles north of the quarry with a 2310′ spread. Through the cooperation of the quarry owners, the firing of the shot was coordinated with the WWV time signals from Washington. The time signals were recorded at both the shot point and spread location. Recordings were made at a pre-arranged time on exact 5 minute intervals as indicated by the time signals. Thus, the firing time was determinable without having radio communication between shot point and recording location.

The first profile recorded refraction energy from the Basement, and possibly the Conrad Discontinuity. It also suggested a reflection from the Mohorovicic Discontinuity. The second profile recorded refraction data from the Basement.

The simplicity of procedures makes it possible for any Geophysical group to record at their convenience without elaborate planning. We plan to expand our operations and hope other societies will become interested in this earth probing project.

INTRODUCTION

In May, 1958, an 81 mile refraction profile was shot parallel to the mountain front in Alberta.* This was made possible through the cooperative efforts of 15 seismic parties and many individuals. A preview of this profile was seen in the fall of 1958 by members of the Geophysical Society of Tulsa. Stimulated by the action of the Canadian geophysicists, a committee** headed by James F. Johnson was organized within the G.S.T. to see if a similar effort could be made in the U. S. Mid-Continent Area. Profiles were suggested across the Ouachita Mountains of Oklahoma, or other similar areas. Letters of inquiry were sent to geophysical societies which we thought might be interested in such a project.

*"Measurement of Thickness of the Earth's Crust in the Albertan Plains of Western Canada," T. C. Richards and D. J. Walker, Geophysics Vol. 24 No. 2.

**The members of the committee are: W. T. Born, Karl Dyk, Henry B. Ferguson, T. S. Green, James E. Hawkins, Paul L. Lyons, James J. Roark, Ben F. Rummerfield, Daniel Silverman, Paul M. Tucker, Kenneth H. Waters, Robert J. Watson, J. A. Westphal, James F. Johnson, Chairman.

The planning and execution of a venture of such magnitude would obviously create many problems. To explore other possible ways of acquiring the same data, the G.S.T., under the leadership of James F. Johnson and J. A. Westphal, conducted a trial program using a routine quarry blast as an energy source. The WWV time signals from Washington were used to coordinate the firing and recording.

The first recording at a distance of 26 miles was most encouraging. Many energy bursts were recorded, one at approximately 15 seconds being particularly interesting. Its time interval, step out, and frequency suggested this might be a reflection from the Mohorovicic Discontinuity, the boundary between the earth's crust and mantle.

Dr. C. Hewitt Dix of the California Institute of Technology, who has been concerned with such phenomena, heard of our recording and asked to join us in further studies.

The timing technique used by the Geophysical Society of Tulsa is not new; with modifications it has been used successfully by others in similar projects. We offer our procedures with the hope that other societies or concerns might become interested. Should such interest be created, the pathway to a long line across the Ouachita Mountains or other areas would perhaps be less tortuous.

INSTRUMENTATION

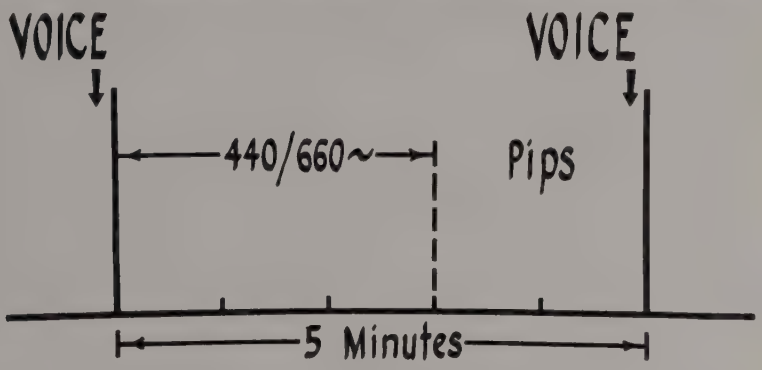
In an attempt to evaluate and anticipate the problems that might arise during the course of a long refraction survey, the committee decided that it would be useful to attempt some shorter refraction profiles in the immediate vicinity of Tulsa.

It was suggested that a possible source of "free" seismic energy was available in local rock quarry blasts, even though the efficiency of the blasts might be small and the effect of an extended detonation time was unknown. An outcrop of the Oolagah limestone forms a large scarp just east of the City of Tulsa where a number of large gravel companies have established quarries; however, the difficulties in utilizing these quarries seemed rather numerous. Contact was made with one of the larger operations and a discussion of the problems with them has yielded a satisfactory solution.

The first problem was that of obtaining a time break. The committee developed a technique which we feel has wide utility in all kinds of seismic shooting where the recording and shooting locations are widely separated. The quarry needs to explode the shot during a certain half-hour period each day immediately following the termination of normal operations, yet not retaining the shooting crew longer than is absolutely necessary. However, it is not important to them at what exact time the shot goes off. Therefore, an arrangement has been made to tell the quarry shooter at what instant to fire the shot during this 30-minute period.

The recording crew is instructed to record an oscillogram at the beginning of each five-minute period during this half hour. Time signals from WWV

are utilized to synchronize and accurately time the beginning of each recording. (Slide 1) A voice announcement of the Eastern Standard time "when



WWV TIME SIGNAL

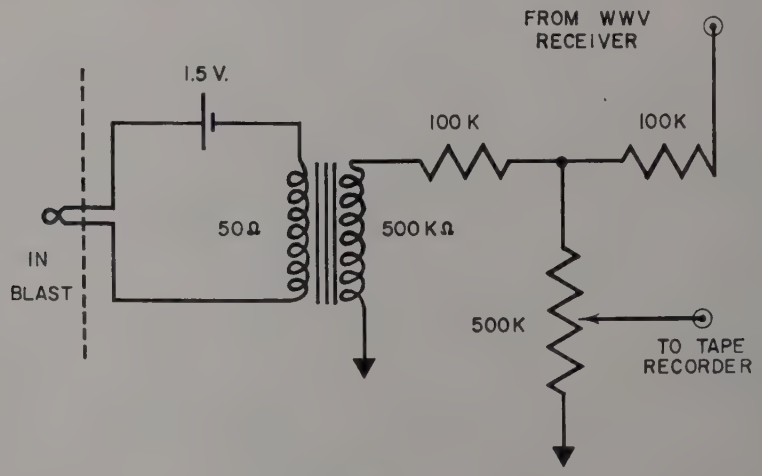
Slide 1

the tone returns" is made on WWV immediately before the beginning of each five-minute period. This voice announcement is usually between 9 seconds and 4 seconds before the five minute break. However, it seems to vary over a range of a few seconds. The first three minutes of each five-minute period has a continuous audio tone background switching between 440 cycles and 600 cycles in alternate five-minute periods. The last two minutes of each five-minute period contain only the "second pips" indicating each second. The 59th second of each minute is missing and the 60th second or zero second is a double pip immediately followed by the beginning of the tone.

The recording unit starts the camera at about the 55th or 56th second and therefore records the beginning of the five-minute period at the double pip and the beginning of the tone. He continues to run the oscillograph for the length of time necessary to record the oscillogram; in the case of a 25-mile offset, usually about 20 seconds. He repeats this procedure for each five-minute period over the half hour during which the shot will be exploded. Since he does not attempt to develop the oscillograms, he usually cannot tell in which five-minute period the energy was received. However, for recording locations within ten miles of the shot the first breaks can usually be seen on the oscillograph as the shot is being recorded and it is not necessary to record any of the following five-minute periods if he is very sure that he has recorded the proper shot. Usually, the recording unit starts the camera immediately after the voice announcement of the time, thus insuring that the beginning of the tone at 00 seconds is recorded.

One of the committee's crew utilizing a stop watch, attempts to fire the shot during the first two or three seconds after the even five minute time. (That is, at 5:30:01 or 5:35:01, etc.) A "Timing" cable with a battery and an ordinary seismic input transformer is utilized in conjunction with an ordinary quarter-inch "home" tape recorder to record both the WWV time signal and a break from the actual explosion. These may be played back later into an oscillograph and the absolute time of the explosion determined within a few milliseconds. The field recording unit also records WWV on the oscillogram. Thus, by utilizing an absolute time scale derived from the radio time signal, a time break may be determined for each recording without the utilization of any communications between the shot and the recording units. Although it may seem to be a little unwieldy at first, this system seems to work very smoothly and the only "loss" is four or five blanks oscillograms.

In this specific instance, the shots normally go off between 5:30 and 6:00 o'clock in the evening. Therefore, no attempt is made to develop the paper records at the recording site or to play back the tape containing the time break information until the next day when it can be done conveniently in one of the laboratories.



Slide 2

In Slide 2, the time break system for recording on the magnetic tape is illustrated. An ordinary flash light battery, connected in series with the low impedance windings of a seismic transformer, is connected to the timing line which runs from the recording location to the shot location, usually a distance of 500′ or less. In one of the shot holes (normally there are many, with various

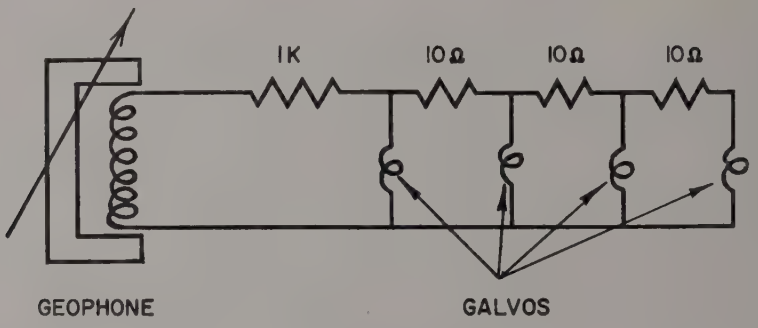
lags, depths, etc.) a loop of No. 22 solid conductor insulated wire similar to ordinary cap wire is inserted, usually by tying the bottom end to a small rock. Since commonly these holes are loaded with ammonium nitrate fertilizer as an explosive, this time break line does not interfere in any way with the loading of the hole. When the shot goes off, this wire is broken and the magnetic field due to the electrical current in the primary of the transformer, decay, producing a large voltage pulse in the secondary. This is fed through the mixing network to the input of the tape recorder along with the WWV output from a radio receiver and recorded by conventional techniques on the tape. The voltage pulse, due to the breaking of the timing cable, is allowed to be sufficiently large to completely saturate the recording amplifier. Thus, when the tape is played back the time break appears as a dead spot overriding the WWV signal and any noise present on the tape, uniquely identifying the time break. This seems to be more satisfactory than any other way of identifying the time break in the presence of high noise levels which are occasionally encountered at this time of the evening.

It is obvious that this technique can be utilized for any number of recording units distributed over practically any area without any need for complicated, and usually unreliable, point-to-point radio communications. Although it would be a convenience to know exactly which five-minute period the shot is going to go off, it is not really necessary for the smooth operation of this system. However, if voice communications were available by telephone or radio between the recording locations and shot point, it would be a convenient addition to the technique.

If the noise level or the ionospheric conditions are such that the voice announcement cannot be heard and the beginning of the tone cannot be recorded, a stop watch, which has been previously set, and the camera is started five seconds before the five-minute period. The oscillograph is then operated until a clean WWV signal is received and the internal timing system of the oscillograph is used to count back and recover the exact time.

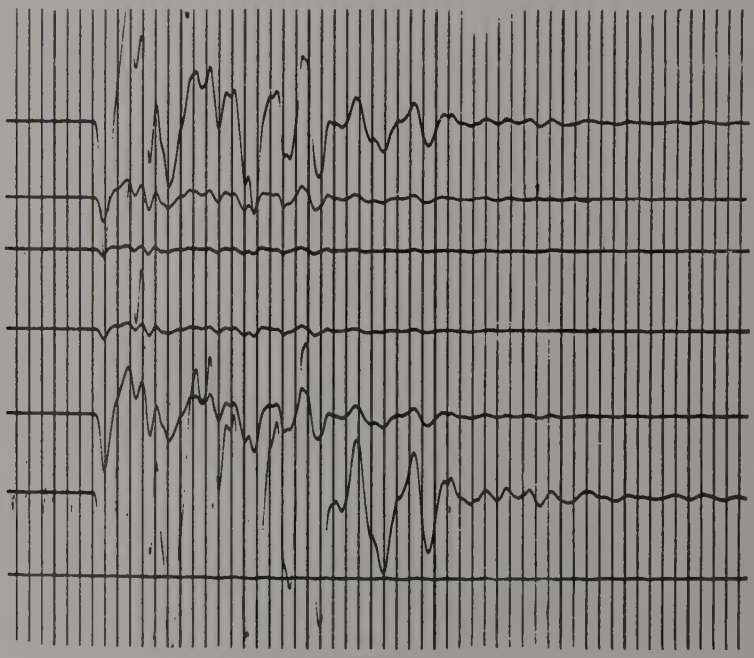
Another of the problems is an evaluation of the effect of the use of delayed shots in the quarry blast. In an attempt to increase the inefficiency of rock fracture and rock movement in quarry blasting, it is common to use "delay caps" which delay the time of explosion of various parts of the charge. Often in the quarry the explosive is distributed in a large number of holes arranged in rows with each row parallel to the rock face detonated at a specific time, usually progressively away from the face. The total lag between the first row explosions and the last row explosions may be on the order of a tenth of a second. The effect of this "distributed explosion" on the seismic spectrum and therefore on the nature of the refracted and reflected wave forms is of interest in the interpretation of the records.

At the suggestion of Doctor C. Hewitt Dix, of Cal Tech, a geophone is "cemented" with plaster of paris into the surface of the Oolagah formation about 100′ from the nearest shot location. This geophone is connected to drive directly, with no amplification, the galvanometers of a small oscillograph



Slide 3

(Slide 3). Since the dynamic range of the signal is great and its level unknown, a dividing network allows simultaneous recording at a number of different levels on the oscillogram.

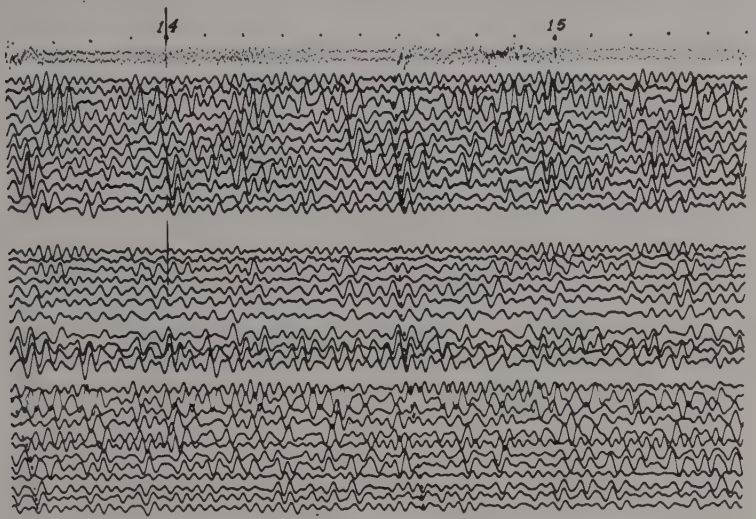


Slide 4

Such a recording is illustrated in Slide 4. The interpretation of this information appears to be complex and has not been sufficiently completed to report in this paper. However, it will be noted that much of the energy seems to be at a frequency of about 30 cycles. This also seems to be the frequency observed in the "reflection" on the recordings. We intend to record such a

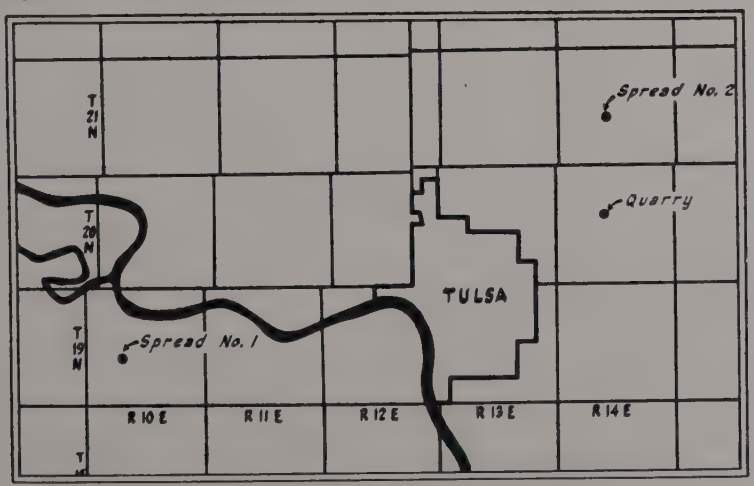
ground motion oscillogram at each explosion in the event that some type of cross correlation or other data manipulation may require the "input" wave form.

The first recordings were made with standard reflection seismic amplifiers and 22 cycle geophones. Since these amplifiers have low response at frequencies below 25 cycles a set of amplifiers were modified to give good fre-



Slide 5

quency and phase response down to 6 cycles. Slide 5 illustrates a simultaneous recording with both equipment utilizing 6 cycle phones. It appears that the



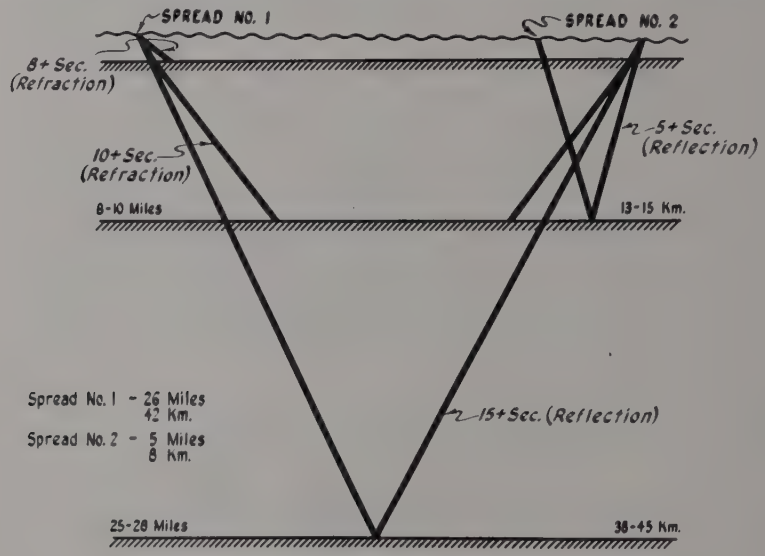
Slide 6

"true" frequency of the "reflection" is about 32 cycles and that ordinary reflection equipment with ordinary geophones is satisfactory.

INTERPRETATION

The areal plan of the set ups is shown on Slide 6. The first recording was a 1210′ spread with 12 traces at a distance of 26 miles SW from the quarry shot. The second recording was a 2310′ spread with 22 traces, 5 miles north of the quarry.

Many energy bursts were recorded on the 26 miles set up after 8.3 seconds. Undoubtedly, many of these were multiples, secondaries, or energy from diverse paths. However, a simple refraction computation (Slide 7) shows that

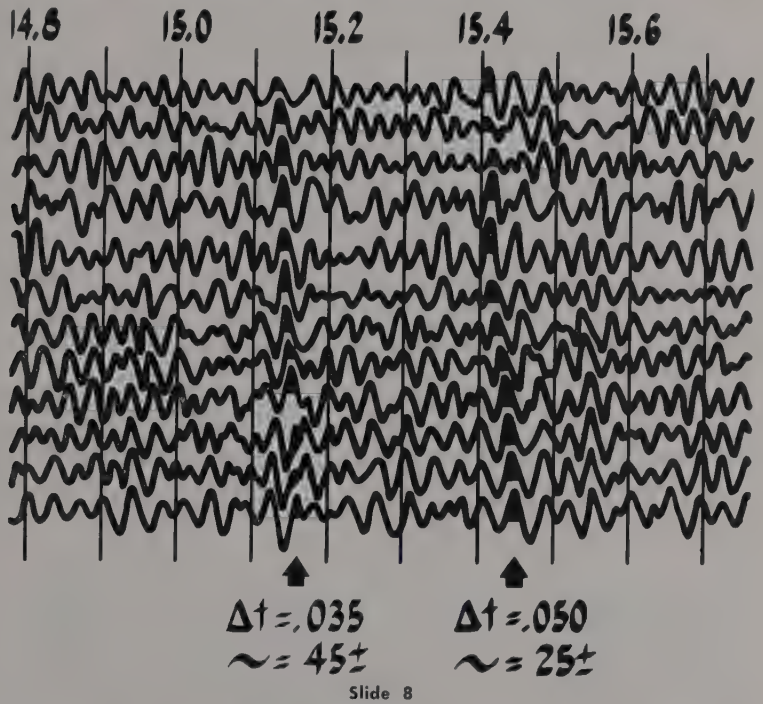


Slide 7

a Basement refraction at 17,000′/sec. could be expected at 8.3 seconds. Further theorizing could also suggest that one of these energy bursts at 9.8 seconds could be from the Conrad Discontinuity. These line ups have a frequency of 25-30 cps.

Of perhaps more significance is a sharp energy burst at 15.1 seconds (Slide 8). The character of this is quite different from the other line ups. Whereas they have a frequency of 25-30 cps and a step out of .045-.055 sec., this has a frequency of 40-45 cps and a step out of .035 sec. If we assume the lower frequency energies are refractions, then perhaps this is a reflection. Using an arbitrary velocity of 18,000′/sec., the 15.1 reflection time would yield a perpendicular depth of approximately 25 miles; a 21,000′/sec. would give a depth of approximately 28 miles. This could be interpreted as being a

reflection from the Mohorovicic Discontinuity. Dr. Dix is in general agreement with these observations and conclusions.



Slide 8

The second recording was taken 5 miles north of the quarry, with a spread of 2310'. The first recorded energy appeared at 1.5 seconds, with a step out of .118 sec. This would suggest a refraction from the limestone overlying Basement. Later energy bursts could possibly be from Basement and/or multiples and secondaries. A sharp energy burst at 5.3 seconds, with a step out of .050 sec. could be a Conrad Discontinuity reflection at approximately 9 miles depth.

CONCLUSIONS

These interpretations are of course highly speculative. Proper identification will come in time as the profiles are filled in and reversed. Of more importance is the fact that energy can be recorded from quarry blasts, and the interpretation fits certain reasonable assumptions concerning the earth's crust.

It is the hope of the Geophysical Society of Tulsa that other societies will become interested in this earth probing project. Perhaps, in the near future we will be able to record long profiles over many areas and add materially to the knowledge of the earth's crust.

Paul M. Tucker
J. A. Westphal

EARTH CRUST MEASUREMENTS BY SEISMOGRAPH IN OKLAHOMA – AN INTERIM REPORT

Geophysical Society of Tulsa

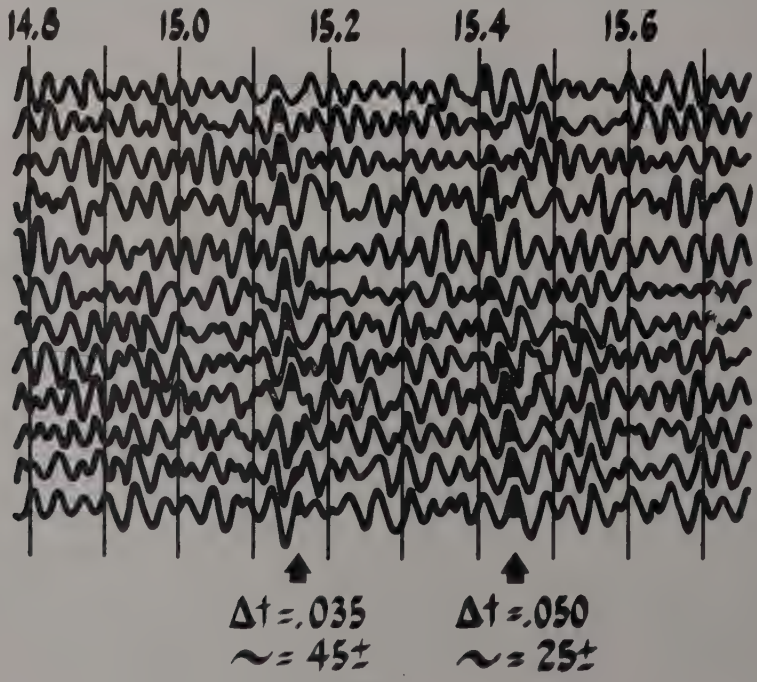
Given At The 30th Annual S.E.G. Meeting In Galveston November 1960

By Ralph D. Lynn

In May, 1958, an 81-mile refraction profile was shot parallel to the mountain front in Alberta.[1] This was made possible through the cooperative efforts of 15 seismic parties and many individuals.

Stimulated by the action of the Canadian geophysicists, a committee was organized within the Geophysical Society of Tulsa to see if a similar effort could be made in the U. S. mid-continent area. Profiles were suggested across the Ouachita Mountains, the Nemaha Ridge and other areas in Oklahoma.

The planning and execution of a venture of such magnitude would obviously create many problems. To explore other possible ways of acquiring the same data, the G.S.T. committee conducted a trial program using routine quarry blasts as an energy source.

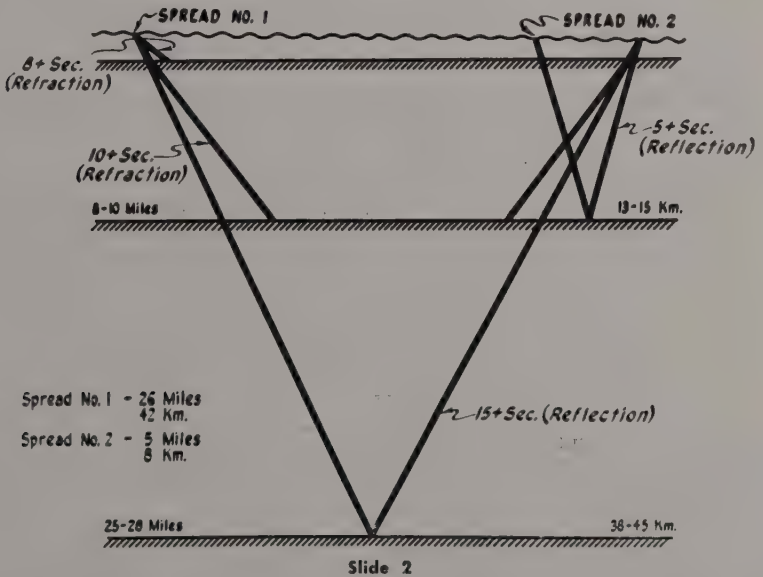


Slide 1

The first recording at a distance of 26 miles from a quarry blast was most encouraging. Many energy bursts were recorded, one at 15 seconds being of particular interest. The time of arrival and time-stepout of this event suggest that it might be a reflection from the Mohorovicic Discontinuity, the boundary between the earth's crust and mantle. This event, shown in Slide 1, arrives at about 15.1 seconds and has a stepout of 35 milliseconds. No effort was made to compute an average velocity from this short (1210′) record. An assumed average velocity of 18,000 feet per second would give a perpendicular depth of approximately 25 miles, whereas an assumed velocity of 21,000 feet per second would give a perpendicular depth of about 28 miles. These depths (25 to 28 miles) are close to the assumed depth to the "Moho" in this area.

The other events on the record are, presumably, multiple reflections of shallower horizons or are refractions. Subsequent shot recordings showed the major events to be reproducible.

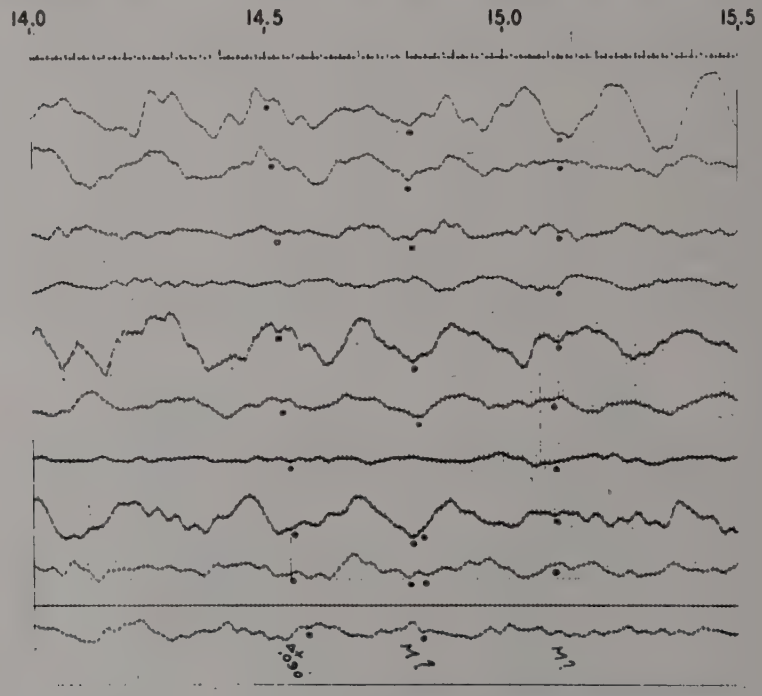
A quarry blast recording was also made at a site 5 miles north of the quarry. This record showed first arrivals at about 1.5 seconds and a presumed reflection event at 5.3 seconds. This reflection would be at a proper time of arrival for a reflection from the Conrod Discontinuity at an approximate depth of 9 miles. The results obtained from these two spreads are summarized in Slide 2. It is believed that this general interpretation is warranted.



Slide 2

Even though the quarry blasts represent "free" energy and the quarry operators have been most cooperative, the shots occur between 5:30 and 6:00 p.m., a time when the ground unrest or noise is high. This observation led to the speculation that a much smaller shot, fired during a quiet time, might be equally effective in obtaining usable data.

This approach has been tried on an East-West profile south of Tulsa. Two shot locations, separated by 18.5 miles, and using a 3420′ spread have been used. Usable records, comparable to those obtained from the quarry blasts, have been obtained from charges ranging from 60 (6 x 10) to 300 (6 x 50) pounds. This shooting program is continuing and it is hoped that, eventually, a full reversed profile will be obtained. Slide 3 shows the type of data being

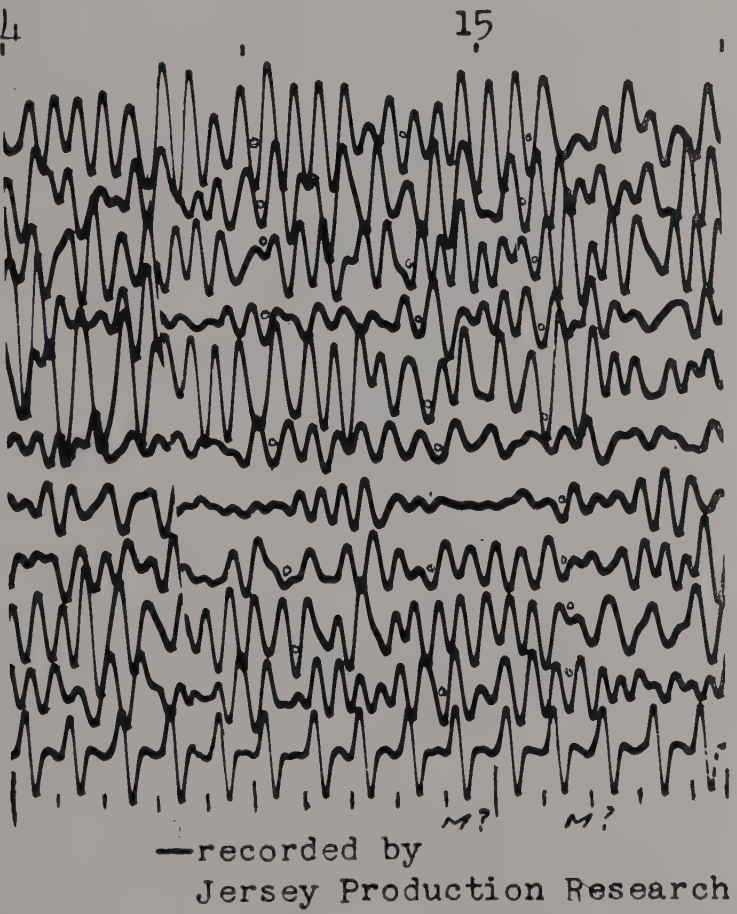


Slide 3

obtained from these smaller charges. Generally, the records appear to be compatible with the quarry blast records. Slide 3 is the unfiltered data. Slide 4, the filtered data.

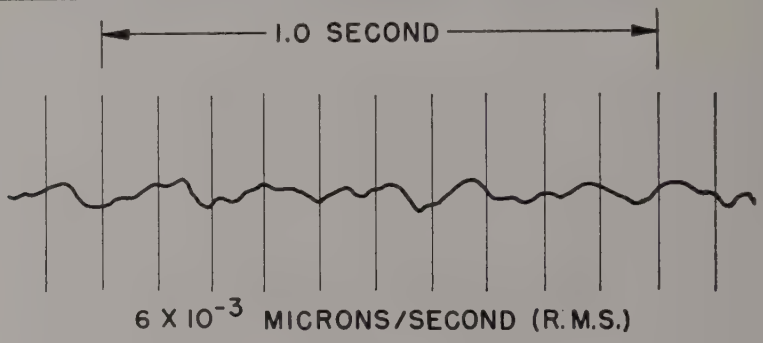
Several by-products have already resulted from this work. Communications are always a problem so several systems have been tried. For the quarry-blast recording WWV time signals are used for shot and recorder synchronization with the actual shot break being tape-recorded with the WWV signal. For the smaller-charge shooting, both 37 mc. direct truck-to-truck communi-

cations and 152 mc. Bell System mobile phones have been used. All three systems work and it is usually desirable to use two of the three systems for each shot, if possible.



Slide 4

Another benefit from this work has been the accumulation of information about ground noise. Slide 5 shows a typical noise trace. This amplitude is equivalent to about 0.6 microvolts at the grid of the first amplifier stage. A frequency analysis performed over a 6 second period of this trace is shown in Slide 6. The frequency spectrum is equivalent to that obtained from a flat-response system, having been corrected for the geophone and amplifier frequency characteristics.

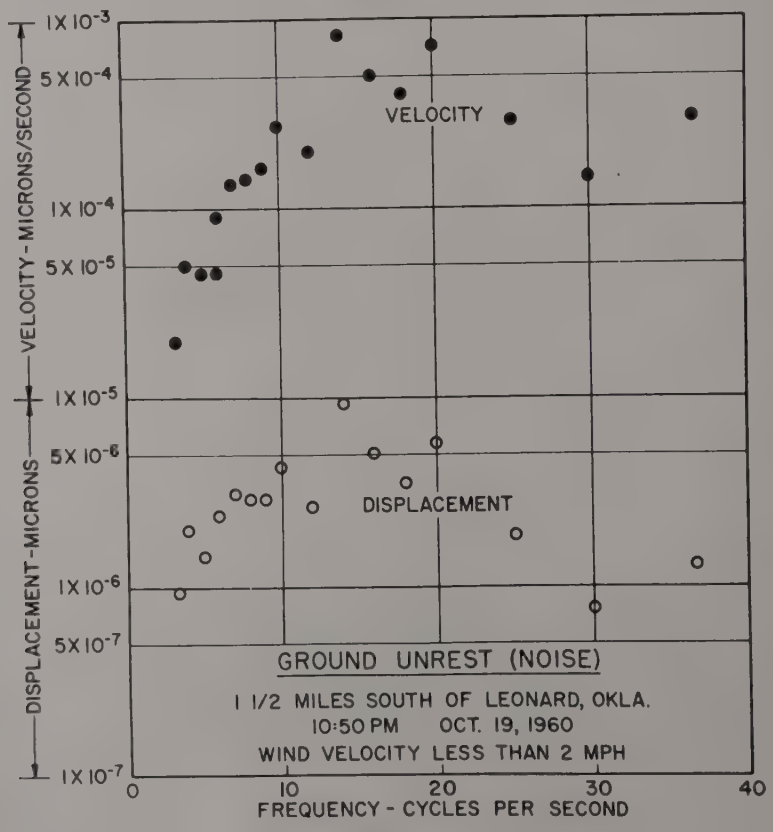


GROUND UNREST (NOISE)

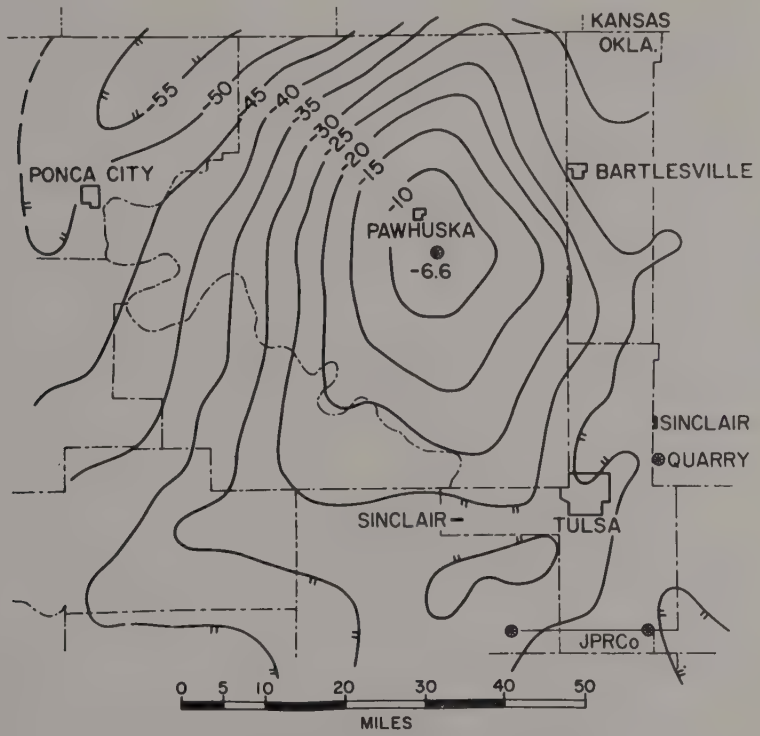
LEONARD, OKLAHOMA

10:50 P.M. OCTOBER 19, 1960
WIND VELOCITY LESS THAN 2 M.P.H.

Slide 5



Slide 6



Slide 7

The noise, shown in Slide 5, is in agreement with the minimum values for earth noise recently published by Brune and Oliver.[2]

The "Moho Committee" of G.S.T. was organized for the purpose of doing basic seismic research. However, this type of shooting, if successful, could have some practical value. An example is shown by Slide 7. The Osage gravity anomaly is a well-known feature, which has been subjected to many interpretations. As is suggested in Slide 8, crustal structure, determined by reflection methods, might provide an answer. Seismic refraction methods would probably not provide sufficient detail.

As president of the Geophysical Society of Tulsa, I wish to acknowledge the support of the following organizations (Slide 9) and Dr. C. H. Dix. Dr. Dix spent the past several months recording in the field and helping the committee.

QUESTION

Is the large positive Bouguer gravity anomaly centering near Pawhuska, Osage County, Oklahoma due in large part to a thinning of the sialic portion of the crust—is it due to an "antiroot" on the Moho surface?

PRELIMINARY INVESTIGATION

The asymmetry of the anomaly suggests an origin due to the combined gravity effects of several anomalous masses at different depths. Assuming that there is one most important deep mass and several shallower masses, possible shapes and depths of a deep anomalous mass were investigated. Assuming, from seismic reflections, that the Moho is at about 27 miles (43 kms.) depth near Tulsa, and that a density contrast of 0.3 exists at the Moho surface, it appears that a mound or "antiroot" of some 9 miles (15 kms.) in height above the "normal" depth at Tulsa will account for the anomaly.

PROPOSAL

A seismic reflection profile near Pawhuska might prove or disprove the existence of the considerable crustal thinning suggested as a possible cause of the gravity anomaly.

Slide 8

Carter Division, Humble Oil & Refining Co.

Pan American Petroleum Corporation

Geophysical Research Corporation

Sinclair Oil & Gas Company

Jersey Production Research Company

Continental Oil Company

Geo Prospectors, Inc.

Century Geophysical Corporation

Seismograph Service Corporation

Sinclair Research Laboratories, Inc.

Slide 9

1. "Measurement of Thickness of the Earth's Crust in the Albertan Plains of Western Canada." T. C. Richards and D. J. Walker, Geophysics, Vol. 24, No. 2.
2. "The Seismic Noise Of The Earth's Surface." J. N. Brune and J. Oliver, Bulletin Seis. Soc. of America, Vol. 49, No. 4, p. 349-353, Oct. 1959.

J. J. Roark

(Dr. C. Hewitt Dix participated in and cooperated with the Geophysical Society of Tulsa in its earth crust measurements. He was asked to contribute to the "Proceedings." His comments follow—*Editor*)

CALIFORNIA INSTITUTE OF TECHNOLOGY

Pasadena, California

August 4, 1961

Mr. Paul M. Tucker
Geological Sciences
Humble Oil and Refining Company
Box 801
Tulsa 1, Oklahoma

Dear Paul:

I must apologize for the delay in answering your letter of July 19. It arrived just as I was walking out the door to take a short vacation which seemed to be rather strongly needed.

I had hoped to get something together for you long before now, but I am afraid about the best I can do is to describe the operation briefly in this letter, and to send you some copies of the records that I have just made. These do constitute the principal results, and I think they will show you very clearly that the problem is still an interesting and vital one, even though a good deal of caution is still necessary in making the interpretation.

The fact that extreme caution is necessary in making the interpretation is certainly nothing new to you, nor indeed to any of the members of the Geophysical Society of Tulsa, who have had experience in the interpretation of seismic records. There are always alternate interpretations possible, although sometimes we are luckier than at other times and the interpretation that we select really turns out to be the correct one.

The present work was carried out at two locations. In the first work, as you recall, the people at Sinclair started the work, and later I joined them, with the help of some of the fellows at the Amerada, to record blasts from a quarry out east of Tulsa. The recording was done west of Tulsa, south of Keystone on the air strip owned by Geo Prospectors, Inc.* The line along this airstrip was not precisely in the direction of the shot point, but was about 20° off to the north. This work with the quarry was, I would say, very successful in showing that interesting results might be obtained, but the problem of extending the line and making anything resembling a velocity profile was out of the question along this particular line, for fairly obvious reasons. However,

*Editors note: Spread No. 1 of the location index map.

before leaving this particular line, I did try a small shot in the early morning hours, and I am enclosing a copy of one of those records.

LOCATION MAP

This showed what was to be expected, namely, that a regular shot fired for the purpose would be much more efficient than the quarry blast, although the quarry blasts were entirely satisfactory, in spite of the fact that the charge used was a distribution not fired simultaneously, but fired over a period something less than a tenth of a second. Success in this respect, I think, depended upon the fact that the major part of the charge was fired at the beginning and simultaneously.

J. J. Roark, of Jersey Production Research Company, and I scouted an east-west line running from about one mile south of the town of Leonard

straight west across country for about twenty miles.* It appeared that a fair part of this line could be entered, and that a certain amount was free of high lines. Practically all of our successful work so far has been done on this line, and I feel that a little more work is necessary in order to make the reflection velocity profile more reliable. At the present time we have a spread which is too short. We can get events which look like reflections shooting in both directions, and I believe that if we can get away from two kinds of disturbances we can successfully complete the line. The disturbances are high line noise and pump noise. This is not to say that other disturbances do not exist, but by proper selection of shooting times we have been able to cut them back to levels where they can be neglected.

The separation between shot and receiver is on the order of nineteen miles, and we seem to receive a basement kick which is transmitted across fairly directly. I don't believe it is a refraction, though it undoubtedly has a little of the refraction mixed with it. Nineteen miles is too far from critical refraction point where the refraction pulse that we ordinarily use is outstandingly strong. So I believe that what we see for the most part on the record consists of waves which are fairly directly transmitted without very much change of character, except that which is unavoidable due to transmission over a path of this length. Coming after the approximate first breaks which come across at a rate of about six kilometers per second, which is to be expected, there are many other events appearing, and these may be combinations of various sorts of events. I have very little doubt that some of them are true reflections. The evidence for this consists of the $\triangle T$ for the events, which shows apparent velocities which are considerably higher than those corresponding to a path straight across. In several cases I have cross-controls, so that I can eliminate the possibility that this is energy, which travels by a shallow path that goes off to the side and is scattered or reflected back to the geophones, and for this reason shows a small $\triangle T$. I think the greatest danger that we have to consider here is the danger due to medium-shallow multiples. I mean by this multiples arising from reflections well into the basement, but which are fairly strong in spite of a rather small velocity contrast or density contrast, simply because of the rather large shotpoint to geophone distance. There appeared to be some real deep reflections and these may possibly be from the base of the crust, but there is still the danger that these apparently deep ones are just multiples. It seems to me that in order to reduce this ambiguity, a successful velocity profile is necessary.

As you know from your own experience, a velocity profile can be extremely valuable and very reliable under favorable circumstances, but if the situation becomes a little more complicated, then the reliability drops off and the problem becomes one of multiple alternate interpretations. Naturally, it can also become one of complete frustration. At the present moment I feel that our problem is one of multiple alternate interpretations, and I should like to push it just a little harder to see if some of the alternates can't be eliminated, if not certainly, then at least with a fair degree of probability.

*Editors note: Spread No. 3 of the location index map.

I should like also to state that as I work on this problem I become more and more convinced of its importance. Certainly if one wishes to map the base of the crust in a rough sort of way, then our ordinary refraction techniques are probably the most reliable, in the sense that they will almost always give some kind of a result. Frank Press and his associates out here have shown that we have an intermediate layer in the crust in this area, and failure to take that into account has had the effect of making the base of the crust appear too shallow, as deduced from ordinary refraction studies. This is one of the uncertainties that is rather hard to eliminate in some cases in connection with refraction work, but I feel that if we are ever to do any detailed work on crustal structure, it will have to be by reflection methods, and if this cannot be done, then we simply cannot do detailed crustal studies. I suppose the problem is somewhat similar to that encountered in the study of the sediments in which there exist favorable locations for study, and there also exist very bad locations for study. Our sample at the present moment is not very great, but I think we have a good enough chance in the neighborhood of Tulsa to justify at least a small amount of further work, and I intend to try to come back to the Tulsa area some time this fall to do this.

One of the problems of interest to me in the Tulsa area is to establish the depth of the Moho by refraction work, and I had thought that this might possibly be done using the quarry blasts, providing sufficiently quiet locations can be found. This will involve shooting probably in a quarry and running a line rather a long distance from the quarry. The problem of finding the quiet place is the major problem, as we cannot hope to succeed without this. From our present reflection information we can guess the depth of the Moho, estimate the velocities, and approximately locate the critical positions. This naturally would be done, but these critical positions are rather a long way from the quarry, so that probably radio communication would be impossible, and it would be necessary to operate using WWV, just as we have in the past. I hope that I can manage such a test this fall.

Yours sincerely,
C. Hewitt Dix

CHD:na

FEATURES OF A DEVICE FOR SEISMIC DEPTH SOUNDING AND RESULTS OF ITS TESTING[1, 2]

G. I. Aksenovich, E. I. Gal'perin and M. A. Zalonchkovskii

Institute of Earth Physics, Academy of Sciences of the U.S.S.R.

(Received 23 May 1956)

ABSTRACT

A description is given of a device developed for a method of seismic depth sounding (SDS) of the earth's crust. The device permits the recording of seismic waves generated by relatively small explosions (50-300 kg of explosives) at distances up to 400 km. from the point of explosion.

The method of seismic depth sounding of the earth's crust (SDS) was proposed by Gamburtsev and was developed under his supervision by an association of co-workers of the Geophysical Institute of the Academy of Sciences of the U.S.S.R. Gamburtsev can be credited for the idea of using a geophysical exploratory type of seismograph for the study of the depth structure of the earth's crust, the selection of frequency responses of the device, and methods of increasing its effective sensitivity. (1, 2) The development and testing of the device was conducted under laboratory and field conditions with the direct participation of the author of the method. The SDS method is based on a wide application of the correlational principles of the recording and tracing of refracted seismic waves generated by relatively small explosions (50-300 kg of explosives) at distances up to 400 km from a point of explosion. (1, 2) The SDS method permits the study of the location and relief of basic boundaries of the earth's crust (all the way to the Mohorovicic limit) in greater detail and accuracy than could be done from observations of earthquakes. With the aid of SDS, information may be obtained on the structure of the earth's crust in any region, including those which are seismically inactive. During recent years an investigation of the structure of the earth's crust in a number of regions of the U.S.S.R. was conducted by this method. Great studies were conducted in the regions of the northern Tian'-Shan' Mts. in 1949, 1950, and 1953, (1, 2) in the Volga-Ural petroliferous province in 1951, in southwest Turkmenistan in 1952, in the Caucasus in 1948 and 1954 and the Pamirs in 1955.[3] The studies conducted produced substantially new data on the structure of the earth's crust. (3-5) At present, the method of seismic depth sounding is being introduced into industry for the purpose of a regional study of the structure of individual regions.

The first tests on seismic depth sounding were conducted in the Serpukhov region in 1939 by the Institute of Theoretical Geophysics of the Academy of Sciences of the U.S.S.R. The studies were undertaken with the purpose of

1. Translated by L. G. Robbins.
2. Reprinted and edited by permission of the American Geophysical Union, publisher of the Bulletin of the Academy of Science of the USSR, Geophysics Series, No. 7, 1957.
3. The results of these studies are given in detail in the scientific reports located in the holdings of the Institute of Earth Physics of the Academy of Sciences of the U.S.S.R.

increasing the depth of penetration of the method of reflecting waves; at the same time measures were adopted for the increase of the effective sensitivity of the device. By means of lowering the frequencies of the oscillations being recorded combined with a grouping of the seismographs, the effective sensitivity of the device was raised considerably, which permitted an increase of the duration of the recording and in individual cases permitted the recording of waves with times of arrival up to 1 min. However owing to the presence of a great number of multiple-reflected waves, the single depth reflections could not be separated definitely. Therefore it was necessary to exclude attempts to use reflected waves for a study of the structure of the earth's crust at great depths. (6)

All further studies on the development of a method of seismic depth sounding were conducted with the use of refracted waves. The main problem consisted of an increasing the depth of penetration of the method. Herein, from the point of view of the device, the problem consisted of how to increase the useful sensitivity with the purpose of receiving seismic waves at great distances which determined the depth of the investigation.

EXPERIMENTAL

Studies. The first tests for the increase of the recording range were conducted in 1940 in the Kovrov-Sudogda region of the Ivanov area. (6) The maximum distance at which explosions were recorded was 40 km. After an eight years' interruption, operations on the study of the depth structure of the earth's crust were renewed in 1948. They were conducted by the Geophysical Institute of the Academy of Sciences of the U.S.S.R. in cooperation with the Institute of Physics and Geophysics of the Academy of Sciences of the Georgian SSR, in the region of the Rion Plains. The purpose of these studies was a clarification of the main possibilities of increasing the range of the reception of seismic oscillations generated by an explosion, and a statement of the basic requirements which a corresponding device should meet. In these studies, the seismographic exploratory station ECHO-1 was used. The observations were begun directly at the point of explosion located in the Black Sea not far offshore. Then the distance between the station and the explosion point was gradually increased. A change to a recording of lower frequencies (15-20 c/s) and a grouping of seismographs permitted a considerable increase in the recording range. The maximum recording distance achieved in these studies comprised 140 km.

The development and testing of the SDS device were most widely realized in 1949 and 1950 in the northern Tian'-Shan' Mts.[1] These studies were vital for the development of the method. Here, together with the problems of the device and methods, certain questions of the study of the structure of the earth's crust were raised and solved. (3, 5) Observations were conducted over a

1. In the preparation and testing of the device during these studies, the following co-workers of the Geophysical Institute of the Academy of Sciences of the U.S.S.R. took part in addition to the authors: I. V. Ashitkov, E. I. Zelikman, S. A. Kulikov, V. D. Pavlov, L. B. Pereverzev and N. O. Chechik.

broad territory between Lake Issyk-Kul' and Balkhash in which the points of explosions were located. In these operations seismic oscillations were recorded, generated by explosions at distances up to 430 km. from the point of explosion. Such a range was achieved owing to the further increase of the effective sensitivity of the device. In this connection, the necessity became clear for changing to still lower frequencies (8-15 c/s), which in its turn permitted the realization of a greater gain in the amplifiers.

In 1949 and 1950, the development and testing of a device for seismic depth sounding were for the most part completed in the Tian'-Shan' Mts., and methods and techniques of observations were also developed.

Description of the device. The SDS device is built in the form of a mobile multi-channel seismic station, and according to the style of seismic geophysical exploratory stations. A great absolute and effective sensitivity is a typical feature of it. An increase in sensitivity in comparison with usual seismic exploratory stations was achieved by means of increasing the strength of the received signals and decreasing the background of internal electrical noises. The increase in effective sensitivity was achieved by the proper selection of frequency responses of the channel and by a grouping of the seismographs.

The proper frequency responses of the device were selected by means of a qualitative evaluation of the predominating spectrum of frequencies of seismic waves and of microseisms. Such an evaluation was conducted with a study of the SDS seismograms obtained with a relatively wide band of passage of the device and also with the aid of special observations of an experimental mobile low-frequency seismic station, possessing great possibilities of a frequency selection in low-frequency ranges. (10) In this it became clear that the predominating spectrum of frequencies of seismic waves at distances of 150-300 km. from the point of explosion changes relatively little, and frequencies from 8-15 c/s predominate. The latter condition determined the selection of a frequency response of individual sections of the seismic channel.

Seismographs. In the capacity of seismic receivers during studies with the SDS, it is advantageous to apply seismographs with a period of natural oscillations of about 6-15 c/s. Exploratory seismographs of a dynamic type are more suitable for these studies. Seismographs of a magnetic type, although they may possess a greater sensitivity than seismographs of a dynamic type, are less stable in connection with a negative magnetic resilience for operations at a low frequency. In the Geophysical Institute of the Academy of Sciences of the U.S.S.R., the ASED (N. E. Fedoseenko, V. P. Kopylov) and SEDS (I. P. Pasechnik, O. I. Kovalev, N. E. Fedoseenko) dynamic seismographs were developed for SDS. The frequency of natural oscillations of the seismographs was 9-12 c/s. The coefficient of electromechanical coupling was 10^8 CGSM. The construction of the device permits a further decrease of the natural frequency.

In SDS, the SP-15 and SPM-16 geophones produced by industry may also be applied. (11) In this connection in the SPM-16 geophones, it is necessary to replace springs with thinner ones (0-2 mm), owing to which the frequency of natural oscillations decreases from 33 to 12 c/s. The simplicity of construction, slight weight and dimensions of the SP-15 geophones create certain advantages in devices of this type over the others. This is particularly important in grouping.

Amplifiers. The principal feature of the SDS amplifier is the displacement of frequency responses into the range of low frequencies. The amplifier is four-stage on resistances with a transformer input and output. The application of highly inductive input and output transformers, an increase in the time constant of the transition circuits (RC), and the rejection of blocking capacitors in the cathode circuits made it possible to obtain a horizontal frequency re-

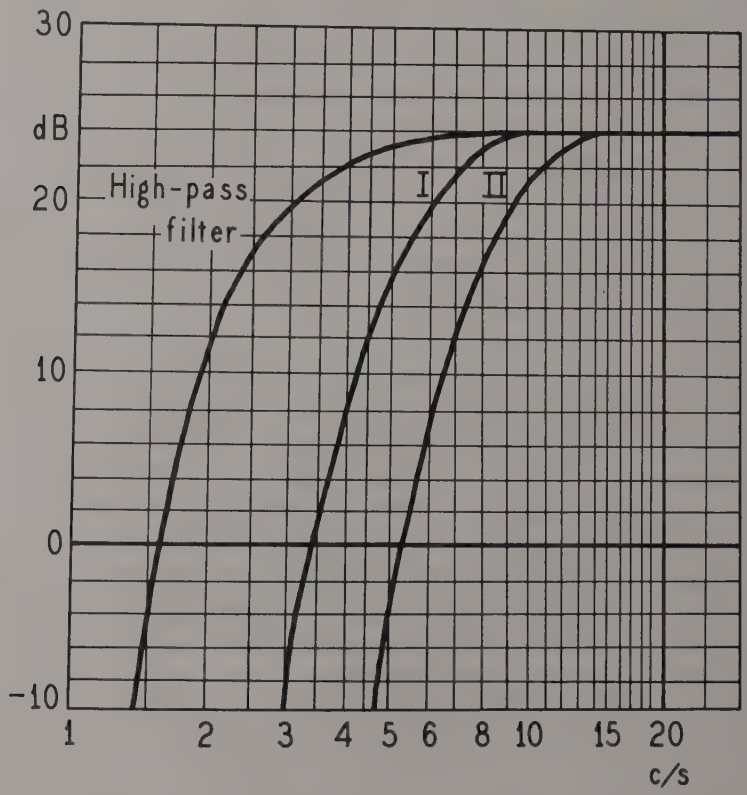


FIG. 1—Frequency responses of high-pass filter.

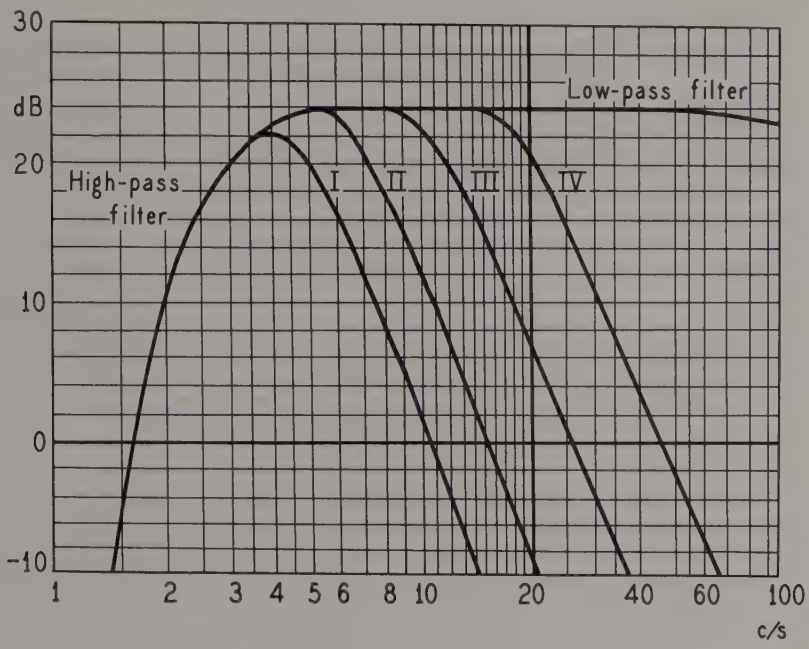


FIG. 2—Frequency responses of low-pass filter.

sponse starting from 4 c/s. The absence of blocking capacitances leads to an increase in stability owing to the presence of negative feedback by current.

Frequency selection was achieved by the application of two filters: high-pass and low-pass, mounted on choke coils and on capacitors. In the amplifier developed by M. A. Zaionchkovskii, the high-pass filter was single-mesh, T-shaped, and had two limiting positions (Fig. 1, I and II); a low-pass filter—single-mesh, II-shaped, which had four limiting positions (Fig. 2, I-IV). Various combinations of the responses of both filters guarantee the possibility of selecting the necessary filtration.

The amplification factor of the SDS amplifier amounts to 750,000 by voltage. For decreasing the background of internal noises in the amplifiers, the first amplifier stage was mounted on a triode 6F5, and the anode loads and tubes of the first amplifier stages were selected with minimum noises. The background of internal noises of the amplifier in working characteristics did not exceed 0.05-0.1 μV. For decreasing high frequency inductions on the line, the outputs of the amplifiers were blocked with capacitances of 0.5 μF.

Oscillograph. A multichannel oscillograph manufactured for seismic field exploration can be used as a recording apparatus. The low frequency of oscillations and the long duration of recording, attaining up to 100-120 sec, led to the necessity of decreasing the recording rate to 8-12 cm/sec.

The decrease in the rate was achieved by a change in the reductor of the tape-winding mechanism. Other types of recording devices may also be used in SDS.

Concerning the sensitivity of the device. The overall sensitivity of the seismic channel can be evaluated by the ratio of the input voltage to the current at the output in microvolts-milliamps. It is convenient to take the amplitude of the recording on the seismogram in millimeters in place of the output current. The amplifier-galvanometer system yields (at a signal at the input of 1 μV), amplitude of 20 mm on the recording, which corresponds to a current at the output of 0.3 mA.

For a determination of the relative and absolute sensitivity of the device, it is advantageous, in addition to the usual audio-frequency oscillators, to apply a magnetic oscillator of constant amplitudes of the MGPA type. (12) Such an oscillator permits a control of the operation of the device and determines all the necessary parameters directly in the field.

On a number of channels of a station. In SDS studies it is advantageous to apply, wherever possible in the observational area, larger seismic stations simultaneously registering explosions. Stations may be used with channels varying in number from 12-60. The selection of the number of channels is determined by observational conditions. As experience shows, it is advantageous under mountain conditions to apply 12- and 24-26 channel stations, and in plains regions 60-channel stations.[1]

The latter can also be applied under mountain conditions with combined positional-azimuth observations. (13, 14)

Grouping of seismographs. Grouping during SDS comprises an important means of increasing the effective sensitivity. Specially conducted experiments (15) demonstrated that with a proper selection of distances between seismographs in the group, grouping facilitates a substantial decrease of the level of the background interferences, wherein the distance between seismographs should be selected according to the index of the loss of phase correlation of microseisms. It is advantageous to use area grouping in SDS.

Results. Over the last 7 years, the device developed was applied with slight changes in studies on seismic depth sounding of the earth's crust in a number of regions of the U.S.S.R. As a rule, the explosions were conducted in natural basins (Black Sea, Issyk-kul' at depth of 20-30 m), however, explosions in small rivers (Bol'shoy and Malyy Cheremshan with a depth of 3-5 m) and in small lakes (Yaskhan, 3 m) also yielded satisfactory results. Observations were conducted at distances up to 400 km under the most diverse seismogeological conditions; in high mountain regions (Kirghiz Range, Pamirs), in transitional regions from geosynclinals to platforms (Turkmenistan, northern Tian'-Shan' Mts.) and on a platform (Bashkiria). The recording of oscillations were conducted directly upon outcroppings of crystalline rocks (Tian'-Shan', Pamirs),

1. Studies on SDS were conducted in 1956 by efforts of the All-Union Scientific Investigatory Institute of Geophysics (VNIIG) in the Volga-Ural region, where four 60-channel stations were used simultaneously.

on the takyrs[1], with a slight stratum (down to 10 km) of sedimentary rocks (Turkmenistan) and under other conditions. In all cases, seismograms were obtained permitting the solution of a number of problems connected with the structure of the earth's crust.

Close local earthquakes were recorded from 1949-1950 during studies of seismic depth sounding in the northern Tian'-Shan' Mts. This made it possible, with the aid of a device of an exploratory type, to carry on the recording of slight local earthquakes at frequencies of 10-20 c/s and served as a beginning for the development of the correlational method of the study of earthquakes (CMSE) (16, 17) and of the so-called high frequency seismometry (seismographic geophysical exploration). (18).

On the basis of the methods and an SDS device, a method of low frequency seismic exploration (LF) was created, being applied successfully in the Volga-Ural petroliferous province for the study of the crystalline foundation.

1. A clayey tract amid sand, ranging in size from 1-2 m^2 to several km^2—Translator.

REFERENCES

1. Gamburtsev, G. A., *Seismic Depth Sounding of the Earth's Crust.* Dokl. Akad. Nauk SSSR 87, No. 6 (1952).
2. Gamburtsev, G. A., *Seismic Depth Soundings of the Earth's Crust.* Trud. Geofiz. Inst., Mosk. No. 25, 152 (1953).
3. Gamburtsev, G. A., Veitsman, P. S., and Tulina Yu. V., *Structure of the Earth's Crust in the Northern Tian'-Shan' Region.* Dokl. Akad. Nauk SSSR 105, No. 1 (1955).
4. Gamburtsev, G. A., and Veitsman, P. S., *Features of Structure of the Earth's Crust in the Northern Tian'-Shan' According to Seismic Depth Sounding Data and a Comparison with Data of Geology, Seismology and Gravimetry.* Trud. Soveta po seismolog. (1955)
5. Gamburtsev, G. A. and Veitsman, P. S., *Comparison of SDS Data on the Structure of the Earth's Crust in the Northern Tian'-Shan' Region with Data of Seismology and Gravimetry.* Izv. Akad. Nauk SSSR (Ser. Geofiz.) No. 9 (1956).
6. Gamburtsev, G. A., *On a Correlational Method for Recording of Refracted Waves.* Izv. Akad. Nauk SSSR (ser. geogr. and geofiz.) No. 2 (1942).
7. Koridalin, E. A., *Study of the Structure of the Earth's Crust by Seismic Methods.* Izd. Akad. Nauk SSSR Moscow (1939).
8. Mintrop, L., *On the Stratification of the Earth's Crust According to Seismic Studies of a Large Explosion and of Earthquakes.* Geophysics 14, No. 3, 321 (1949).
9. Bune, V. I., and Butovskaia, E. E., *On a Hodograph and Structure of the Earth's Crust in Central Asia According to Recordings of Powerful Explosions.* Trud. Geofiz. Inst. Mosk. No. 30, 157 (1955).
10. Zapol'skii, K. K., Gal'perin, E. I., and Borisevich, E. S., *Experimental Mobile Low Frequency Seismic Station.* Trud. Geofiz. Inst. Mosk. No. 29, 156 (1955).
11. Slutskovskii, A. I., *Electrodynamic Seismograph, Exploratory and Industrial Geophysics.* Gostoptekhizdat No. 13, Moscow (1955).
12. Fedoseenko, N. E. and Groshevoi, G. V., *Method of Controlling the Sensitivity and a Determination of the Frequency and Amplitude Responses of Seismic Receiving Channels with the Aid of a Magneto-Electric Oscillator.* Izv. Akad. Nauk SSSR (ser. geofiz.) No. 5 (1953).

13. Gamburtsev, G. A. and Gal'perin, E. I., *Asimuthal Seismic Observations with Inclined Seismographs.* Izv. Akad. Nauk SSSR (ser. geofiz.) No. 2 (1954).

14. Gal'perin, E. I., *Azimuthal Method of Seismic Observations.* Gostoptekhizdat, Moscow, (1955).

15. Veitsman, P. S., *On Choice of Distances Between Seismographs in Grouping for the Purpose of Decreasing Background Interferences.* Izv. Akad. Nauk SSSR (ser. geofiz.) No. 6 (1952).

16. Gamburtsev, G. A., *On a Correlational Method of Study of Earthquakes.* Dokl. Akad. Nauk SSSR 92, No. 4 (1953).

17. Gamburtsev, G. A. and Gal'perin, E. I., *Method of Operations According to the Correlational Method of Study of Earthquakes.* Izv. Akad. Nauk SSSR (ser. geofiz.) No. 1, (1954).

18. Gamburtsev, G. A., *On High Frequency Seismometry.* Dokl. Akad. Nauk SSSR 88, No. 5, (1953).

AN EXPERIMENTAL APPLICATION OF THE SEISMIC DEPTH-SOUNDING METHOD TO THE INVESTIGATION OF THE STRUCTURE OF THE EARTH'S CRUST IN PARTS OF WESTERN TURKMENIA* [1]

by

I. P. Kosminskaya and Yu. V. Tulina

Academy of Sciences U.S.S.R., Institute of Physics of the Earth

(Received 8th December 1956)

ABSTRACT

The following paper contains an account of results obtained from seismic depth soundings (SDS)** taken in certain regions of Western Turkmenia for the purpose of investigating the structure of the earth's crust. The features peculiar to the seismic boundaries situated at various depths, corresponding to the surfaces of the palaeozoic, granitic, basaltic and subcrustal layers, are described; and charts are given, showing the palaeozoic surfaces and thicknesses of the crust. The maximum crustal capacity was found in the Caspian depression (over 40 km) and the minimum (under 30 km) in the Bol'shoi Balkhan. The crustal sections were compared with the focal depths of weak earthquakes recorded at high-sensitivity RWCM stations (refracted wave correlation method).**

In 1952 special work on the study of the depth structure of certain regions in Western Turkmenia was inaugurated in connection with detailed investigations into the seismicity of the territory of Turkmenia. The method used for this work was the seismic depth sounding method (SDS) suggested by Gamburtsev and developed in the Geophysical Institute of the Academy of Sciences of the U.S.S.R. under his direction. (1, 2) The basic problem for investigation was to elucidate the character of deep division boundaries in the region of the joining of the basic geological structures situated in the area concerned. To this category belongs the Kopet-Dag and Bol'shoi Balkhan ridges (Great Balkhan range) the Turkmenian or cis-Kopet-Dag flexure and the Caspian depression (Fig. 1). The term "deep boundaries" was taken in the sense of boundaries lying at depths of a few kilometers (usually more than five) up to several tens of kilometres, which cannot be investigated by the usual geological and geophysical prospecting methods.

The SDS work was done by the staffs of two organizations, the Geophysical Institute of the Academy of Sciences of the U.S.S.R. and the Central

*Translated by K. Syers from Isv. Akad. Nauk SSSR, ser. geofiz. No. 7, 874-894 (1957) (Reprint order No.: GEO 110).

**Translator's note: Russian—GSZ (glubinnoe seismicheskoe zondiravanie); KMIZ (See reference (10))

1. Reprinted and edited by permission of the American Geophysical Union, publisher of the Bulletin of the Academy of Science of the USSR, Geophysics Series, No. 2, 1957.

Asian Board of Petroleum Geophysic of the Ministry of the Oil Industry of the U.S.S.R. It was expected that investigation of the deep structure of the region would lead to the solution of certain methodological problems involved in increasing the depth of seismic prospecting under the conditions met with in Turkmenia. The work was under the scientific direction of Gamburtsev, who was directly responsible for directing the field observations and the interpretation of the results obtained.* The present article deals with the main findings of these investigations.

1. SEISMOLOGICAL CONDITIONS IN THE REGION.

Work was done in the Balkhan and Danatinsk corridors, in the eastern part of the Caspian depression and between the town of Kazandzhik and Kizl-Arbat. A number of observations were made in the Kizl-Arbat-Ashkhabad direction (Fig. 1). The principal explosion points were in Lake Yaskhan—in the old Uzboi feed-channel (Yaskhan explosion point), and in the Caspian Sea, south of Krasnovodsk (Krasnovodsk explosion point).

Seismological conditions.

The operational area is situated in the region of the development of an extremely thick cenozoic deposit consisting of sandy clay and carbonaceous rocks. The general cenozoic thickness in the region of the Turkmenian flexure and the Balkhan corridors is of the order of 6-8 km., and in the region of the Caspian depression is more than 10 km. (3, 4). In the region of the Turkmenian flexure, it is assumed that there is a monolithic palaeozoic basement composed of metamorphic rocks underneath the thick cenozoic.

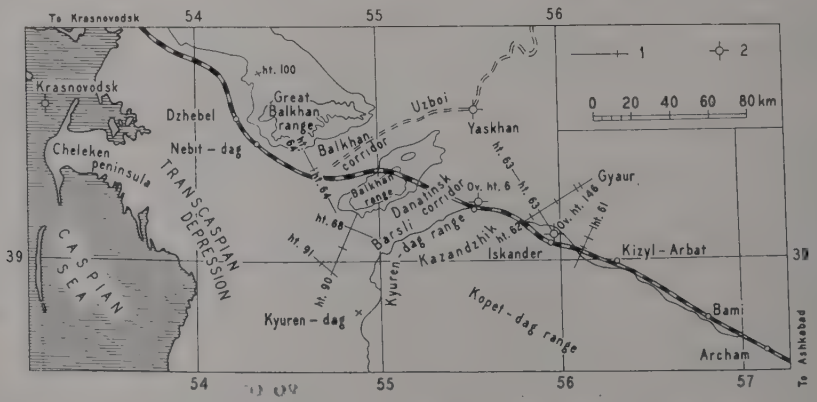


FIG. 1—Map showing disposition of the profiles. 1—Seismic profiles. 2—Explosion points.

*Apart from the authors of the present article, a large group of investigators from the Geophysics Institute of the Academy of Sciences of the U.S.S.R. collaborated in the work of the SDS expedition. N. E. Fedoseenko was in charge of technological matters; M. A. Zaionchkovskii led the field group; E. I. Zelikman was the operator; and S. A. Kulikov was in charge of the explosion points. Yu. N. Godin, Chief Engineer of the Central Asian Petroleum Board, assisted in examining the working plans and the results.

The velocity section of the region was studied to a depth of 3-5 km. According to the seismo-prospecting, and also the seismo-core-sampling* data on reflected and refracted waves, the mean velocities down to these depths are 3-3.5 km./sec. In the surface thickness, layers with boundary velocities of 2.5 to 4.5 km./sec. were encountered. For certain layers at the foot of the cenozoic deposit (limestone of the Cretaceous), the boundary velocities were as high at 6-6.5 km./sec.

The south-western region of Turkmenia is characterized by the presence of an extremely thick cenozoic formation of low average velocity. This circumstance gave rise to many misgivings in planning the SDS work in the Turkmenian region, since the SDS method had previously been used only under conditions of almost total absence of sedimentary deposits (Tienchang, 1949 and 1950 (2)).

A number of experiments in receiving distant explosions had also been carried out in Bashkir (1950 and 1951), where the sedimentary thickness extends to 2 km., and the average velocity in this thickness is of the order of 4.5-5 km./sec. The fact that the average velocity in the Turkmenian sedimentary rocks was low, while the extent of the thickness was considerable (of the order of 10 km.) and the rocks composing it would apparently be bound to possess great absorption, gave rise to doubts whether in these circumstances we would be able to obtain energy corresponding to the deep crustal division boundaries —in particular that of the Mohorovicic discontinuity—with the usual SDS seismic apparatus. (5) These doubts were strengthened by the fact that there are no large natural water reservoirs in western Turkmenia in which effective explosions could be produced. But the first experiments in tracing explosions in the old Uzboi channel-bed showed that the Turkmenian conditions were favorable for the reception of distant explosions and for obtaining traces at great distances (up to 250 km.) from the explosion point although the explosions were of low force.

2. METHOD

For the recording of seismic traces at great distances from the explosion point we used a low-frequency SDS apparatus (5) constructed in the Geophysics Institute of the Academy of Sciences of the U.S.S.R. This had a maximum characteristic amplifier frequency of 8-12 c/s. The seismological stations were equipped with SP-10 seismographs with their own frequency of 13.5 c/s. The observations were all carried out on exactly similar instruments.

Interference

Under the Turkmenian conditions, the main source of interference was the wind, which was so strong, especially in the daytime, that we sometimes had to work at night. The microseisms caused by wind have frequencies of around 30-40 c/s, so that when the wind is weak they are not usually very noticeable on traces with maximum frequency characteristic filtration of around 10 c/s.

*The seismo-core-sampling work was carried out by the Central Asian Petroleum Geophysics Board.

The wave groups, and principles for separating them.

On the seismograms, individual waves, correlated according to phase, are separated out. Such waves are sometimes traced over considerable intervals of the profile (10-12 km.), but in most cases the correlation breaks down. One wave gives place to another, or a regular wave simply disappears and new regular waves are observed in the time region roughly corresponding to the arrival time of the wave that has vanished.

By adopting the principles suggested by Veitsman* we succeeded in identifying a number of groups among the waves recorded. Each group is characterized by the following peculiarities: the separate wave groups have approximately similar arrival times, and the graphs of their phases lie in a certain "band" (Fig. 2). The inclinations of the graphs of the separate waves are approximately similar; this corresponds to the approximately similar values of their apparent velocities. Each of the groups corresponds to an appropriate maximum on the A(t) curve.

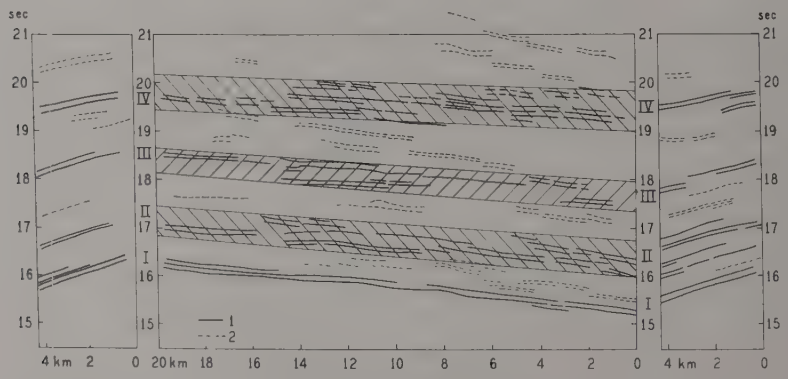


FIG. 2 — Graphs of basic wave groups profile 64, Yaskhan explosion point. The shaded bands reflect the preferential inclination of the phase hodographs of individual waves in the group. 1 — graphs of waves of basic groups. 2 — graphs of waves of which the nature is not clear.

On traces obtained in the platform area at distances R of up to 90 km. from the explosion point, only one group of waves was identified. On traces from the folded zone, at distances R of up to 110 km., four groups of waves were recognized. The waves of these groups, traced over long uninterrupted profiles (about 40 km.), differ in mean values of their apparent velocities V* determined from the cross-section of the profiles by intervals which correlate and correspond to the intensity of A_k/A_i (Table 1).

*Correlation of Seismic Waves from Seismic Depth Sounding of the Earth's Crust. Institute of Physics of the Earth, Academy of Sciences of the U.S.S.R.

TABLE 1

CHARACTERISTICS OF WAVE GROUPS

(YASKHAN EXPLOSION POINT)

Wave group	Maximum correlation intervals of separate waves in the groups				V*, km/sec				A_k/A_1 k = I, II	
	pr. 64†	pr. 68†	pr. 90†	pr. 91‡	pr. 64	pr. 68	pr. 90	pr. 91	pr. 68	pr. 90
I	10	12	8	—	5-8	6	6	—	1	—
II	6	8	7	8	7-17	6-7	4-7	5-6	1-3	1
III	6	6	8	—	11-16	6-8	4-6	6-7	1-6	2-4
IV	6	6	5	3	9-22	9-10	5-10	6	3-12	2-7
Distance from explosion point, km	80-82	78-84	76-105	103-105						

† Transverse profiles.
‡ Longitudinal profile.

From Table 1 it follows that the first group of waves is the weakest in intensity and the most extensive in correlation potentiality. It also has the smallest apparent velocity (of the order of 5 km./sec.). The most intensive is the fourth group, which has the smallest intervals of correlation and the greatest apparent velocity (over 8 km./sec.). The second and third groups are intermediate both in intensity and in intervals of correlation and values of apparent velocities.

The most characteristic feature of the Balkhan sections and the Bol'shoi Balkhan is the presence of a fourth group of waves with high apparent velocities. This group was traced over a large area in the region of the Balkhan and Danatinsk corridors and adjacent parts of the Transcaspian depression, at distances of 70 to 110 km. from the explosion point. We should mention that at shorter distances from the explosion point (about 60 km.) in the Danatinsk corridor observations, we did not succeed in isolating this group of waves. It may be presumed that refracted waves of the fourth group appear only at distances from the explosion point of the order of 70-80 km. To judge from the calculations, the region of the point of origin of the waves in this group is to be found at these distances from the explosion point.

As the distance from the explosion point increases ($R > 110$ km.) the wave picture changes, the relative intensity of the fourth wave group diminishes. In the distance interval 130 to 150 km. a zone of interference is observed, in which it becomes difficult to separate the waves into groups. At distances R of over 150 km. from the explosion point, two groups of waves can be recognized, the third and fourth. Group IV waves are traced as Group I,

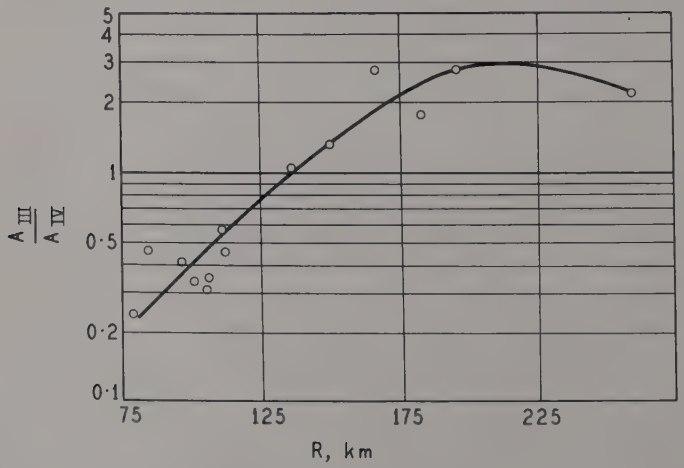


FIG. 3—Curve of the dependence of the ratio A_{III}/A_{IV} of the amplitudes of group III and IV waves on the distance R from the explosion point. Constructed from data of traces for the Yaskhan and Krasnovodsk explosion points.

and possesses less intensity than Group III waves.

Figure 3 shows the curve of the dependence of the ratio A_{III}/A_{IV} of Group III and IV wave amplitudes on the distance R from the explosion point. Near the point of origin ($70 < R < 100$ km.) this ratio is about 0.3; over the distance interval $170 < R < 220$ km. it increases until it attains a maximum of about 3. At greater distances from the explosion point, the curve is seen to fall.

Analysis of the curve shows that its form is conditioned by the difference in the divergence of the fronts of wave groups III and IV.

In identifying the waves obtained from explosions in the Yaskhan and Krasnovodsk points, we made use of the dynamic and kinematic peculiarities of the wave groups, and also of what may be called the average T (R). The t(R) graphs were constructed from observation points situated in sections of similar geological structure. Thus all the explosion points were combined into a single point. To identify wave groups distributed over separate profiles we used group correlation principles. The averaged graphs made it possible to compare the Turkmenian and the Tienchang data (6, 7) and determine the nature of the waves more reliably.

4. NATURE OF THE WAVES

Analysis of the data obtained experimentally showed that the first waves of the separate groups were longitudinal vertical waves corresponding to seismic boundaries situated at various depths. The subsequent waves in the different groups, to judge from their velocity magnitudes, also seem to be mainly longitudinal, but their kinematic character is not clear at present. Some of these waves seem to be connected with seismic boundaries inside the granite and basalt layers.

A comparison of the SDS data on the depths of the division boundaries and the apparent wave velocities corresponding to them, with the seismological (8-13) and geological (3, 4) data, and also with the SDS data obtained in Tienchang (6, 7, 14, 15) leads us to conclude that the following is the most plausible hypotheisis for the relationship between the seismic and the geological boundaries:

Wave Group	SDS Seismic Boundaries	Geological Boundaries	Provisional Designations For Sections
I	I	Palaeozoic surface	P_g
II (P°)	II	Pre-Cambrian (granitic layer)	d°
III (P*)	III	"basaltic layer" surface	d*
IV (P)	IV	sub-crustal (substratum)	d
		surface of Mohorovicic surface	

Zones of abrupt break in wave continuity.

Breaks in the correlation of deep waves in the Balkhan region are in most cases also accompanied by complication of the traces for waves corresponding

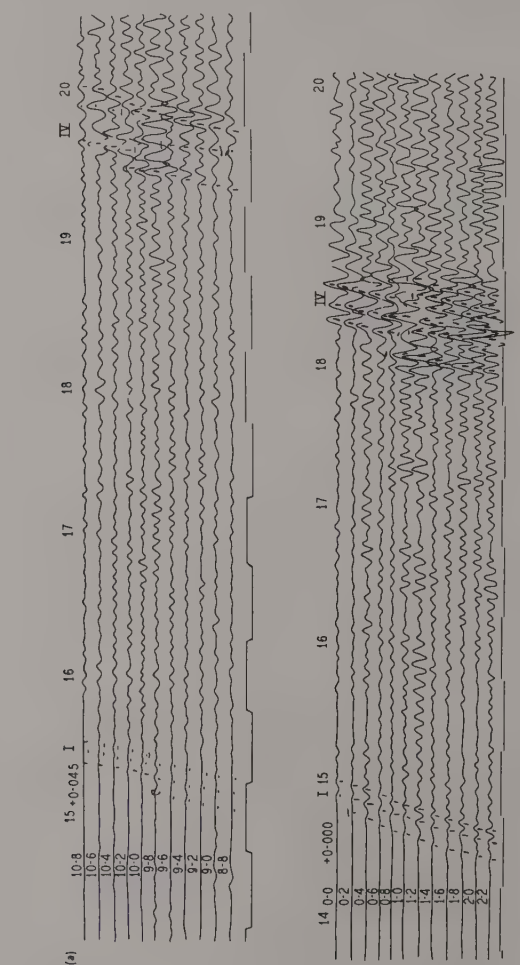


FIG. 4—Seismograms illustrating similar form of traces of group IV waves at the northern (a) and southern (b) extremities of profile 64.

to the smaller boundaries. This usually makes it impossible to determine the depth of the break zone with any confidence. In one case, however, we did succeed in identifying fairly confidently the displacement even of the deep boundaries. In the Balkhan corridor, profile 64, explosions at the Yaskhan explosion point yielded traces which showed a difference in the arrival times of the deep group IV waves traced at the southern and northern extremities of the profile (Fig. 4). This difference (which was of the order of 1.5 seconds, as can be seen from the graph shown in Fig. 5, points 28-33) is not accompanied by any significant displacement of the graphs of the first waves, corresponding to the smaller boundaries.

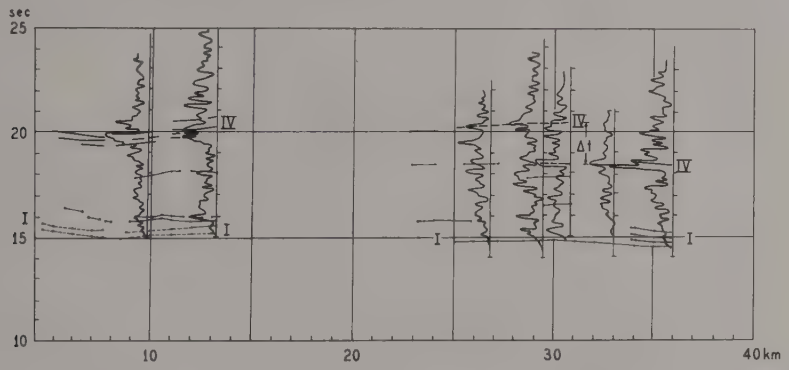


FIG. 5 — Graphs of group I and IV waves, profile 64, Yaskhan explosion point. On the northern part of the profile the arrival times of group IV waves are roughly 1·5–2·0 sec less than at the southern extremity. The difference in arrival times of group I waves is about 0·5 sec. The character of the group IV wave traces in the southern and northern parts of the profile is shown in Fig. 4.

6. THE DEEP DIVISION BOUNDARIES

Under the heading of deep division boundaries we shall include those boundaries which lie below the level of the Palaeozoic surface; that is, the Granitic surface (d^0), the Basaltic surface (d^*) and the Sub-crustal (d) layers.

Apparent velocities.

The values for the apparent velocities, determined from the crossing of the profiles for the corresponding deep boundaries, vary greatly in the different parts of the observation area. Some parts with high velocity values can be seen (profiles 68, 90, the Kyuren-Dag and Barsli cross-sections, the Krasnovodsk explosion point), others with normal velocities like the boundary velocities (the Gyaur cross, the Krasnovodsk explosion point and profile 68, the Yaskhan explosion point), and still others with low values (profile 90, the Yaskhan explosion point).

Comparison of the velocity data with the behavior of the Palaeozoic surface shows that the reason for the divergence of the apparent velocities from the normal values corresponding to horizontal boundaries in the region of profiles 68 and 90, is the relief of the deep boundaries themselves, since the

inclinations of the Palaeozoic surface are either insignificant or are in the opposite sense to any which could lead to a rise in apparent velocities. Qualitatively, the picture of the distribution of velocities for waves of Groups III and IV is evidence that these boundaries rise on the Kyuren-Dag side.

TABLE 2

VELOCITY VALUES TAKEN IN CONSTRUCTING THE CROSS-SECTIONS AND CHARTS

Waves	Boundaries	Velocity, km/sec		
		V_{st} Stratum Velocity in sub-boundary layer	V_b Velocity along the boundary	$\overline{V}$ Mean Velocity In Medium Above Boundaries
P° (II)	surface of granite layer d°	5.5	6.5	4.0
P* (III)	surface of basalt layer d*	6.3	6.3	5.0
P (IV))	surface of sub-crustal layer (Mohorovicic boundary) d	8.0	8.0	5.5

Velocities taken in calculating.

In order to determine the depths and form of the boundaries, it was necessary to have values for the mean velocity $\overline{V}$, the stratum velocity V_{st} and the boundary velocity V_b. The magnitudes of V_{st} and V_b were chosen on the basis of seismological data (11-13) and the SDS data for northern Tienchang. (7)

From the SDS data in Turkmenia we were able to construct only the individual values for the mean velocity $\overline{V}$ at the points of intersection of the graphs of I, II, III and IV waves and the co-ordinates of the point of origin of the graph for the Group IV waves. These values were entered in the velocity column (Fig. 6) constructed from the seismological data. (3, 8, 10). They are practically similar to the $\overline{V}(H)$ curves calculated from this column.

Table 2 gives the values for the layer, boundary and mean velocities taken in constructing the charts and cross-sections for the deep boundaries. From this table it can be seen that the values for mean velocities in media lying above the surface of the basaltic (boundary III) and the subcrustal (boundary IV) layers are smaller in Turkmenia than in other regions. This is explained by the presence of the extremely thick (over 10 km) section of sedimentary cenozoic with low mean velocity (under 4 km/sec). According to the seismological data for other regions (11-13) the velocity in the superbasaltic thickness is 5.5 km/sec and the mean velocity in the earth's crust around 6 km/sec. (11)

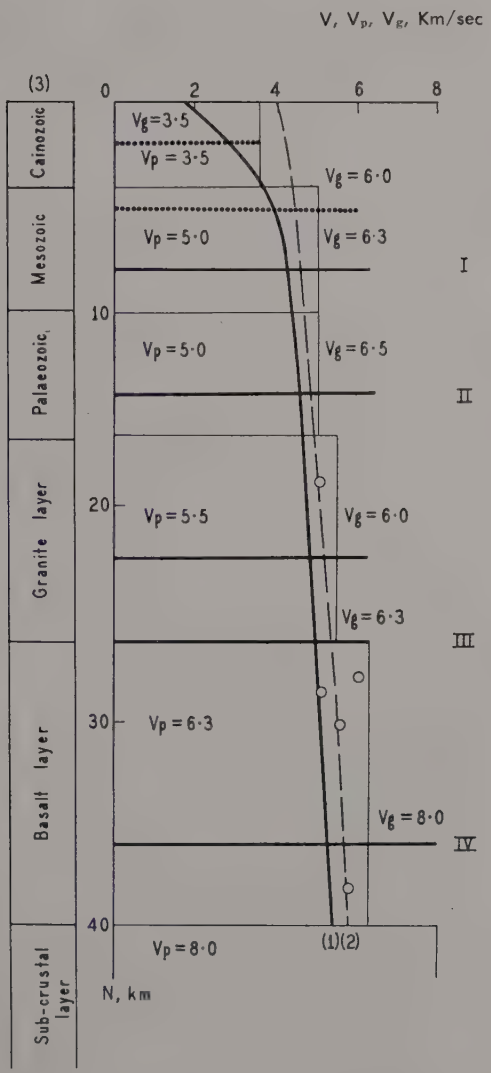


FIG. 6—Velocity column (constructed from seismogeological data). Curves of the variations of mean velocity with depth. (1)—for the Transcaspian depression region; (2)—for the Bol'shoi Balkhan region; (3)—section; o—values of $\bar{V}$, determined from SDS data; $\bar{V}g$—boundary velocities taken in constructing the SDS boundaries.

Depths of boundaries d and d*

The system of observation was not adequate for precise determination of the depths. Values for the mean depths $\overline{H^*}$ and $\overline{H}$ of division boundaries d* and d were determined from the approximative formula of Gamburtsev.

$$\overline{H} = \frac{\overline{V}}{2 \cos i_{12}} \left(\frac{t - R \cos \overline{\varnothing}}{V_b} \right) ,$$

where $\overline{H}$ is the mean value of the depth of the division boundary between the explosion point and the observation point situated at distance R from the explosion point; t is the arrival time of the first waves corresponding to the division boundary for which the magnitude of $\overline{H}$ is being determined; $\overline{V}$ is the mean velocity in the medium above the boundary; $\overline{V_b}$ is the boundary velocity; i equals $\sin^{-1} (\overline{V}/V_b)$;$\overline{\varnothing}$ is the mean angle of inclination of the division boundary. When $\varnothing < 10°$ $\cos \varnothing \cong 1$.

The following data were obtained for the d* boundary (surface of the basalt layer): in the Balkhan region and the adjacent north-eastern part of the Transcaspian depression, the magnitude of $\overline{H^*}$ equals 14-17 km; in the region of the Bol'shoi Balkhan $\overline{H^*}$ equals 12-14 km.

For the d boundary (Mohorovicic surface) in the region of the Balkhan and Danatinsk corridors and the Transcaspian depression, we have: $\overline{H}$ equals 34-36 km, in the Kizyl-Arbat region $\overline{H}$ equals 32-35 km, and in the Bol'shoi Balkhan $\overline{H}$ equals 25-28 km.

Thus the maximum mean depths for the d* and d boundaries were observed in the region of the corridors and the Transcaspian depression, and the minimum in the Bol'shoi Balkhan region. The mean depth h* of the basalt layer was around 15-18 km in the corridor region and 13-15 km under the Bol'shoi Balkhan.

True depths

The values for the mean depths in the case of a sloping boundary may differ substantially from the values for the true depths H_0 at the explosion point and H_1 at the observation point of H_1 at the point of emergence of a ray; H_0 and H_1 are the depths towards the interrupted boundary, according to the normal. To calculate the H_1 depths for the Mohorovicic boundary the following computations were made: from the given values of $\overline{H}$ and H_0 the magnitudes of H_1 at the observation point were calculated according to the formula: H_1 equals $2\overline{H} - H_0$.

The value of the depth H_{01} for the Yaskhan explosion point was taken equal to 30 km, on the basis of calculations of the mean depths in this part. For the H_{02} depths (Krasnovodsk explosion point) three values were taken: H_{02} equals 27, 30 and 33 km. The limits of variability of H_{02} were chosen on

the basis of comparing the values of H_1 computed for identical observation points according to the data from explosions at Yaskhan and Krasnovodsk explosion points.

In order to assess the influence of seismic destruction, the depths H'_1 were also determined at the point of mergence of a seismic ray with given values of H_0 and t with the help of the solution of the direct problem. Here it was assumed that the boundary was flat and the velocities $\overline{V}$ and V_b constant. The values for H_1 determined in this way were entered on the topographical map. On the same map we entered the values of H_1 computed for both points according to the formula cited above. A chart of the crustal capacity was then composed.

Estimates of possible errors show that the method used for determining values for H_1 and H'_1 can give the absolute depths to a degree of accuracy of the order of $\pm$ 5 km. The magnitude of the error is determined in the main by the inexact choice of a value for H_0 at one of the explosion points. A comparison between the variants of the charts constructed for different values of H_0 shows that the discrepancies do not involve any question of principles. Fig. 7 shows the crustal capacity chart worked out for values of H_{01} equals 30 km and H_{02} equals 33 km.

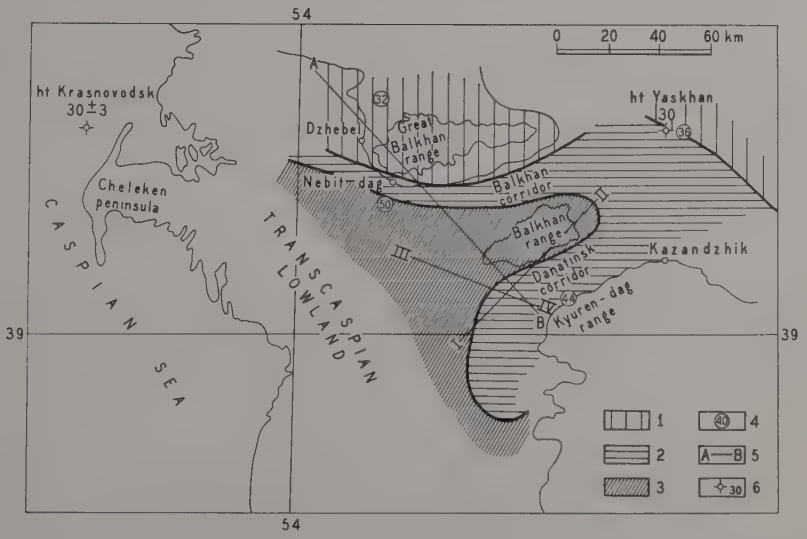


FIG. 7—Chart of thicknesses of earth's crust in the south-western region of Turkmenia according to SDS data.
1—thickness H < 30 km; 2—30 to 40 km; 3—H > 40 km; 4—depths according to ANDREEV;[8] 5—lines according to which the sections were constructed; 6—explosion points and crustal thicknesses taken from calculations for the region of each explosion point.

For the d* boundary, corresponding to the surface of the basalt layer, estimates of the true depths H_1 at the observation points were not made, since

for this boundary we did not succeed in separating out the P* waves reliably at all the observation points. Moreover, judging from the data from the Turkmenian and Tienchang cross sections (6, 7, 14, 15) the d* boundary is characterized by a much more complicated relief than the d boundary, and there is less justification for assuming a flat form for this surface.

Crustal thickness chart

On the crustal thickness chart shown in Fig. 7, the regions of high and low values of the crustal thickness are given. The lowest crustal thickness (less than 30 km) is observed in the region of the great Balkhan range, and the highest (over 40 km) in the Transcaspian depression. The transition zone between these regions and the region of the Balkhan corridor is characterized by crustal thicknesses of from 30 to 40 km., a sharp fall-away of the Mohorovicic boundary being observed on the Transcaspian depression side. From observations at particular points in connection with the explosions at the Yaskhan explosion point, the following depths were established for the Mohorovicic boundary in the Ashkhabad direction: Bami, 32 km.; Archman, 36 km.; Megin, 40 km.

Comparison with the gravimetrical data.

A comparison of the crustal capacity chart with the gravitational anomaly values shows that the basic regional anomalies are connected with the position of the Mohorovicic boundary. In the Great Balkhan, where the gravitational anomalies $\triangle g$ are around 20 mgal (Bouguer reduction) the depth of the Mohorovicic boundary is under 30 km., while the Transcaspian depression, where $\triangle g$ equals -70 mgal the depth is over 40 km. We note that a similar regularity was also established for Tienchang. (6, 7, 14, 15). A more detailed analysis of the connection between the relief of the deep boundaries and the character of the gravitational field for Western Turkmenia is given by Yu. N. Godin.[1]

The Cross-sections.

In order to elucidate the behavior of the deep boundaries in comparison with the shallower ones, sections were constructed along the line of the profiles. Figs. 8 and 9 show sections for profiles I-II and III-IV, the disposition of which was shown in Fig. 7.

The section along the line I-II was constructed from the survey area data in connection with the explosions at the Yaskhan explosion point, and the section along the III-IV line from the individual line graphs obtained in connection with the explosions at the Krasnovodsk explosion point. The supporting depths were taken on the basis of calculations of the mean depths. The velocity values are shown on the sections. From these sections the discrepancy between the division boundaries can be easily seen. A particularly sharp discrepancy is noticeable between the d* and d boundaries (profile I-II). On profile III-IV an abrupt rise of the d* boundary on the Kopet-Dag side is observed.

[1] Report, **Complex geophysical Investigations of the Depth Structure of the Earth's Crust on the Transcaspian Model**, at the Conference of Geophysicists in December 1955. (Novosibirsk)

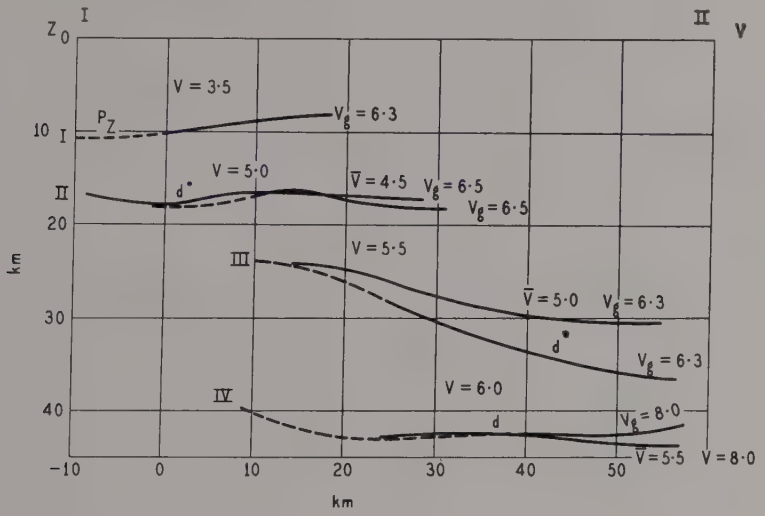


FIG. 8—Section of deep boundaries according to the line I-II (Fig. 7). Under the Danatinsk corridor the surface of the basaltic layer is observed to rise. Above the parts of the boundaries constructed without taking refraction into account, the values taken for the mean velocities are shown.

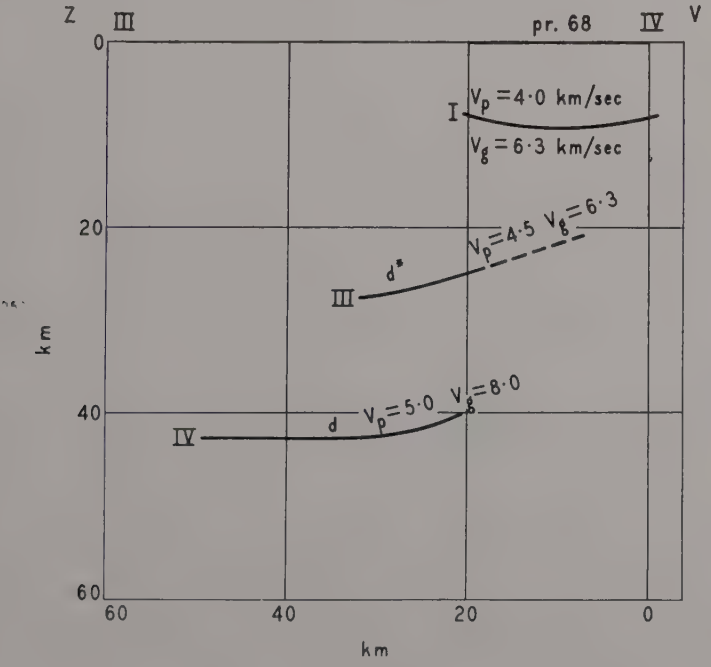


FIG. 9—Section of deep boundaries according to lines III-IV (Fig. 7). The basaltic layer is seen to rise from the north-west to the south-east on the Kopet-Dag side.

Thus the regions of Western Turkmenia which have a different geological history are characterized by different crustal structures. Fig. 10 shows section diagrams of the earth's crust for the Transcaspian depression, the Danatinsk corridor, the cis-Kopet-Dag flexure and parts of the platform in the regions of the Bol'shoi Balkhan and Lake Yashhan.

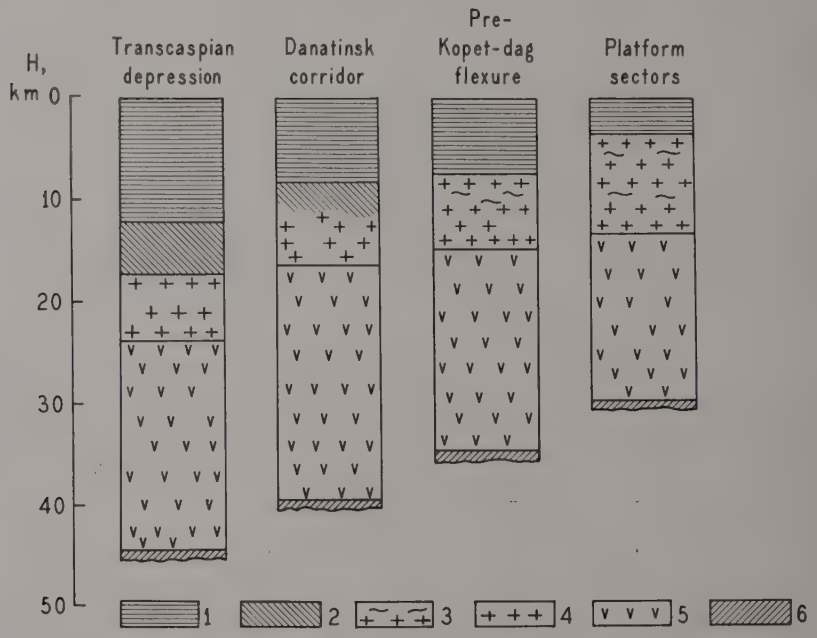


FIG. 10—Diagrammatic sections of the earth's crust for the regions of Western Turkmenia.
1 —— Cenozoic deposits; 2—palaeozoic deposits of folded regions; 3—granitic layer including the palaeozoic basement platform; 4—granite layer; 5—basalt layer; 6—sub-crustal layer (sub-stratum).

General Conclusions

1. The southwestern regions of Turkmenia are suitable for the recording of distant explosions (100-250 km.) by SDS methods.

2. The SDS observations yielded traces of wave groups corresponding to division boundaries over a wide range of depths; from prospecting depths of 3-10 km. to the basalt and sub-crustal layers 20-45 km. deep.

3. The experimental SDS work carried out in Turkmenia showed that by going over to lower frequencies (10-20) c/s) and using distant explosions, it is possible to increase the refracted wave method prospecting depth to a significant extent. At distances of 30-80 km. from the explosion point, it is

possible to study division boundaries situated at depths of 3-10 km. With the aid of SDS apparatus, it is possible to record explosions produced not only in reservoirs, but also in boreholes.

4. The character of the traces is evidence of the complex seismo-geological structure of the south-western region of Turkmenia throughout the whole range of depths. In this connection, a study of the influence of the seismic boundaries lying higher up is essential, in order to elucidate the nature of the behavior of the deep contours. For this purpose it would be advisable to combine observations by SDS and by the refracted wave correlation method.

5. Comparison of the P* and P wave traces obtained in Turkmenia with the traces obtained by SDS in Tienchang (6-7) shows that the kinematic and dynamic peculiarities of the wave groups in both regions are similar. The groups are made up for the most part of separate waves, an effect apparently connected with the complex layer structure of the earth's crust. An explanation of the nature of subsequent waves in the groups is one of the main SDS methodological problems.

Geological-geophysical Conclusions.

Four seismic boundaries were identified as a result of the SDS work in Turkmenia. The shallowest of these is related to the surface of the Palaeozoic basement; the deeper ones correspond to the surfaces of the Granitic, Basaltic and Sub-crustal layers.

Deep Boundaries.

1. The West Turkmenian SDS data show that areas which have different geological histories are characterized by a different crustal structure. The deep seismic boundaries connected with the surface of the granite, basalt and subcrustal layers in the western regions of Turkmenia have a complex form.

2. A depth chart was constructed for the surface of the granite layer d° in the western district of the Danatinsk corridor and the part of the Transcaspian depression adjacent to it. The maximum depth reached was 16-18 km. Comparison of the iso-depth chart for this boundary with the iso-depth chart for boundary I shows that these boundaries are practically consonant in the Danatinsk corridor region, and sharply at variance in the area of transition to the Transcaspian depression.

3. The surface of the basalt layer was traced only on individual profiles Its relief is complicated. The depth of the basalt surface varies from 12-14 km. in the Great Balkhan to 20-25 km. in the Transcaspian depression.

4. A depth chart was constructed for the Mohorovicic surface. The thickness of the crust in the region of the Great Balkhan is less than 30 km., and in the Transcaspian depression 40 km. or more. The most abrupt decline of the Mohorovicic boundary was noted in the transition zone from the Great Balkhan to the Transcaspian depression. In the Yaskhan-Ashkabad direction, the Mohorovicic surface falls away at an angle of about 3°. The relief of the

Mohorovicic boundary is in good agreement with the character of the gravitational field. Small crustal thicknesses correspond to positive regional gravitational anomalies, and large thicknesses to negative anomalies.

5. Comparison of the SDS sections with the depths of weak earthquake foci recorded at ESCM stations shows that the foci of the main groups of earthquakes are concentrated in the granite, in the basalt, and in the lower part of its boundary—the Mohorovicic surface.

REFERENCES

1. Gamburtsev, G. A., *Seismic Depth Sounding of the Earth's Crust.* Dokl. Akad. Nauk SSSR No. 6 (1952).
2. Gamburtsev, G. A., *Seismic Depth Sounding of the Earth's Crust.* Trud. geofiz. inst. Akad. Nauk SSSR No. 25, 152 (1954).
3. Petrushevskii, B. A., Rezanov, I. A., and Rastvorova, V. A., *Seismological Characteristics of Turkmenia.* Izv. Akad. Nauk SSSR, ser. geofiz. No. 2 (1954).
4. Petrushevskii, B. A., Rezanov, I. A., Rastvorova, V. A., and Leonov, N. N., *On the Tectonics of Western Turkmenia.* Bull. O-va ispytat, prir. otd. geol. 29, (4) (1954).
5. Gamburtsev, G. A., Aksenovich. G. I., Gal'perin, E. I., and Zaionchovskii, M. A., *Basic Features of an Apparatus for Seismic Depth Sounding, and Test Results.* Izv. Akad. Nauk SSSR, ser. geofiz No. 1 (1957).
6. Gamburtsev, G. A., Veitsman, P. S., Davydova, N. I. and Tulina, Yu. V., *Seismic Depth Sounding of the Earth's Crust in Northern Tienchang.* Bull. Sov. seismol. Akad. Nauk SSSR No. 3 (1957).
7. Gamburtsev, G. A., Veitsman, P. S. and Tulina, Yu. V., *Structure of the Earth's Crust in Northern Tienchang According to Seismic Depth Sounding Data.* Dokl. Akad. Nauk SSSR 105, No. 1 (1955).
8. Andreev, S. S., *Depth Structure and Seismicity of Turkmenia.* Candidate's dissertation. Geofiz inst. Akad. Nauk SSSR (1953).
9. Andreev, S. S., *The Iso-surface Method in Interpreting Local Earthquakes.* Izv. Akad. Nauk SSSR, ser. geofiz., No. 2 (1954).
10. Andreev, S. S. Masarskii, S. I., Rustanovich, D. N. and Kharin, D. A., *Investigations of Weak Earthquakes in South-western Turkmenia.* Izv. Akad. Nauk SSSR, ser. geofiz. No. 2 (1954).
11. Reinhardt, H. G., *Stembruchsprengungen Zur Erforschung des Tieferen Untergundes.* Freiberger Forschungshefte, Geophysik. Akademie Verlag, 15 Berlin (1954).
12. *Report of the Special Committee on the Geophysical Study of Continents,* 1952-1954. Trans. Amer. Geophys. Un. 36, No. 4 (1956).
13. Savarenskii, E. F., and Kirnos, D. P., *Elements of Seismology and Seismometry* (2nd Ed) Gostekhizdat (1955).
14. Gamburtsev, G. A. Veitsman, P. S., *Features of the Structure of the Earth's Crust in the Region of Northern Tienchang According to SDS data, and a Comparison with Geological, Seismological and Gravimetrical Data.* Bull. Sov. seismol. Akad. Nauk SSSR No. 3 (1957).
15. Gamburtsev, G. A., and Veitsman, P. S., *A Comparison of Data on the Structure of the Earth's Crust in the Region of Northern Tienchang with Seismological and Gravimetrical Data.* Izv. Akad. Nauk SSSR, ser. geofiz. No. 9 (1956).
16. Gamburtsev, G. A., Riznichenko, Yu. B., Berzon, I. S., Epinat'eva, A. M., Pasechnik, I. P., Kosminskaya, I. P. and Karus, E. V., *Refracted Wave Correlation Method.* Akad. Nauk SSSR Moscow-Leningrad (1952).
17. Gamburtsev, G. A. and Gal'perin, E. I., *Method of Work for Correlation Method of Studying Earthquakes.* Izv. Akad. Nauk SSSR, ser. geofiz. No. 1 (1954).
18. Gamburtsev, G. A., *Present State and Future Prospects of Work in the Field of Earthquake Prediction.* Bull. Sov. seismol. Akad. Nauk SSSR No. 1 (1955).

ABSTRACTS OF SELECTED SOVIET PAPERS ON EARTH CRUST MEASUREMENTS

DYNAMIC METHODS OF INVESTIGATION OF THE EARTH'S INTERNAL STRUCTURE AND CRUST

V. I. Keilis-Borok; Review of Paper, XI Gen. Assem. Intern. Union Geod. & Geophys., Toronto, Sept. 1957; *Intern. Geol. Rev.* v. 1, No. 5:64; May 1959 (Soviet-In English).

The author presents a method of determining the internal structure and crust of the earth. This method eliminates the solution of elasticity theory equations and analyzes instead the structure of boundary conditions. By using this method, one can determine the various thicknesses of the layers of the earth; the existence, incline, and strike of the boundaries of these layers; and, less accurately, the ratio of velocities at these boundaries. A formula is shown which can be used for building theoretical seismograms for refracted, reflected, and head waves in multi-strata media. (Longer English abstract available.)

ATTEMPT AT THE DETERMINATION OF THE THICKNESSES OF THE LAYERS OF THE EARTH'S CRUST

G. Demetrescu; *Ceskoslovenska Akad. Ved Studia Geophys. et Geod.* v. 2, No. 3:293-295; 1958 (In French).

Certain weak impulses at regular intervals between the P and S arrivals noted in Rumanian records of deep earthquakes in the Vrancha region in the Carpathians are interpreted on the assumption of a two-layer crust. These waves are then used to determine crustal layering under three different hypotheses which give, respectively, thicknesses of 41, 23, and 23 km for the granitic layer, 21, 33, and 34 km for the basaltic layer, and 78, 84, and 83 km for the depth of focus below the Mohorovicic discontinuity, from records of the earthquake of July 10, 1943.

WAVE GUIDES IN THE EARTH'S CRUST AND SUB-CRUST LAYER

V. A. Magnitskiy; *Byull. Moskovsk. Ob. Ispyt. Prirody: Otd. Geolog.* No. 4:15-23; 1958 (In Russian).

This article discusses wave guides in the earth's crust and sub-crust layer, their causes, the heterogeneity of the sub-crust layer and the relation of the earth's crust to the underlying layers. A graph shows a scheme of the distribution of the velocities of seismic waves in the earth's crust and in the upper sections of the shell, according to B. Gutenberg.

DETERMINATION OF THE THICKNESS OF THE EARTH'S CRUST ACCORDING TO OBSERVATIONS OF THE DISPERSION OF LOVE WAVES

E. F. Savarenskii and D. I. Sikharulidze; *Izv. Ak. Nauk SSSR, Ser Geofiz.* No. 6:880-883; June 1959 (In Russian).

Results of the recording of Love waves at Tbiliosk, from earthquake epicenters located in eastern Africa, central Asia, China, Japan, and the Pacific Ocean, were analyzed and compared with earlier results obtained from the

recording of Rayleigh waves. Crustal thicknesses of 35 ± 5 km to 55 ± 5 km were indicated. These data are in agreement with those published earlier by Ewing and Press.

ON THE DETERMINATION OF THE AVERAGE THICKNESS OF THE EARTH'S CRUST FROM RAYLEIGH WAVE GROUP VELOCITY MEASUREMENTS

E. F. Savarensky and S. S. Ragimov; *Bull. Acad. of Sci. USSR, Geophys. Ser.* No. 9:969-971; July 1960 (Soviet—In English).

The determination of the mean thickness of the earth's crust for large regions, such as continents or oceans, can be based upon dispersion phenomena in surface waves of the Rayleigh and Love type. This study makes use of data from twelve earthquakes recorded in the Caucasus. This study assumes a one layer continental crust but suggests that some errors found may be due to a multi-layer crust. The average thicknesses found in the regions studied were computed as being between 15 and 35 km. Assuming a single layered crust, the average thickness between the Caucasus and the Philippines Deep is greater than the crust thickness between the Caucasus and the Philippine Islands, Taiwan, and the Samoa Islands. The crust thickness is greater between the Caucasus and the Aleutians and Kuriles than between the Caucasus and the Samoa Islands, Taiwan, and the Philippines.

THE STRUCTURE OF THE EARTH'S CRUST ACCORDING TO SEISMIC DATA

I. P. Kosminskaya; *Byull. Moskovsk. Ob. Ispyt. Prirody: Otd. Geolog.* No. 4:25-38; 1958 (In Russian).

The author reviews seismic data on the structure of the earth's crust. He considers the results of detailed studies made in various regions of the USSR by means of plutonic seismic research and concludes that data on the structure of the crust obtained by seismic and gravimetric research make it possible to divide the crust according to thickness and structure into continental and oceanic zones. Research on the continents showed that the thickness of the crust varies in platform and folding areas. Results obtained during detailed studies indicate the difference in structure of the earth's crust of ancient and young platforms and also of folds of various ages. Thus, important connections between the plutonic structure of the crust and the structure of its upper sections, which are accessible to geologic research methods, can be established. The determination of a regularity of these connections and their geologic-geophysical analysis throws light on the complex process linked with the formation of geological structures. (39 References)

THE DEEP-SEATED STRUCTURE OF THE EARTH'S CRUST UNDERLYING THE BLACK SEA SOUTHWEST OF THE CRIMEA ACCORDING TO SEISMIC DATA

Yu. P. Neprochnov; *Doklady Ak. Nauk SSSR* v. 125, No. 5:1119-1122; 4/11/59 (In Russian).

The author reports on the method and results of a marine seismic refraction survey conducted in an area southwest of the Crimean Peninsula. Data obtained from two profiles are discussed in detail. A comparison of the results of this survey with the well-known results of other surveys of the structure

of the earth's crust in continental and oceanic regions shows that the earth's crust beneath the Black Sea is different. The thickness of the crust in this area is 22-24 km, i.e., less than that in continental areas and greater than that in oceanic regions. In the absence of a granitic layer, the earth's crust beneath the Black Sea is more like that of the oceanic type; however, it has a much thicker sedimentary section (8-12 km). It is interesting to note that the Gulf of Mexico has an almost analogous crustal structure. It also has a sedimentary section overlying rocks with a seismic wave velocity of 6.2-6.4 km/sec at a general crustal thickness on the order of 20 km.

SEISMIC DATA REVEAL NATURE OF THE EARTH'S CRUST UNDER THE BLACK SEA

Y. P. Neprochnov, Black Sea Experimental Station; *Byulleten' Moskovskogo Ispytateley Prirody, Otdel Geologicheskiy* No. 1:119-120; 1960 (In Russian).

Seismic exploration revealed an 8- to 14-km layer of clay and sedimentary rocks beneath the floor of the Black Sea near the Crimean Peninsula. Below this is basalt 6.4 to 6.8 km thick. This basalt layer is only 10 km below the surface near Crimea, but is 15 km in the central part of the Sea and 20 km in the direction of the Kerch Strait. The Earth's crust under the Black Sea differs substantially from both continental and oceanic types of crust.

SEISMIC DATA ON THE STRUCTURE OF THE EARTH'S CRUST IN THE CENTRAL PART OF THE BLACK SEA

Yu. P. Neprochnov, V. P. Goncharov, and A. F. Neprochnova, Inst. of Oceanology USSR; *Doklady Akad. Nauk SSR* v. 129, No. 2:408-411; 11/11/59 (In Russian).

In the summer of 1958 regional seismic studies were conducted in the central part of the Black Sea for defining the structure of the Earth's crust in this region. The region of operations embraced the central part of the deep-water depression of the Black Sea and the zone of the continental slope to the south and southeast from the Crimean peninsula. A detailed echometric survey of the bottom of the region was conducted simultaneously with the seismic work. A comparison shows that the structure of the earth's crust in the central part of the Black Sea basin is similar in general outline to the structure of the earth's crust of the Southwest of Crimea beyond the limits of the continental slope. A short time ago, attention was turned to the fact that the mountainous part of Crimea, in contrast to other elevations of the Alpine geosynclinal region, is characterized by great positive anomalies of gravity in a Bouguer reduction.

SEISMIC INVESTIGATION OF THE EARTH'S CRUST IN CENTRAL ASIA

V. I. Ulomov; *Izv. Akad. Nauk SSSR, Ser. Geofiz.* No. 1:3-5; 1960 (In Russian).

Cross sections of the earth's crust and iso-depth maps for individual regions in central Asia are the results of deep seismic sounding investigations performed in late 1957. Records from a total of 29 permanent and temporary seismic stations disposed along a zone about 100-km wide enabled the author to draw a cross section through the earth's crust for a distance of about 1000 km. The acoustic energy came from a powerful explosion, otherwise not described. Several anomalies were present, and good agreement with previous deep seismic sounding profiles and gravity information is claimed.

STRUCTURE OF THE EARTH'S CRUST IN THE PAMIR-ALEYSK ZONE ACCORDING TO DATA FROM DEEP SEISMIC SOUNDINGS

I. P. Kosminskaya, G. G. Mikhota, and Yu. V. Tulina; *Izv. Akad. Nauk SSSR: Ser. Geofiz.* No. 10:1162-1180; Oct. 1958 (In Russian).

Results are presented of a study of the earth's crust by a deep seismic sounding method in the Pamir-Aleysk zone. Two seismic boundaries identified with the surface of a basaltic stratum and the surface of the Mohorovicic discontinuity, are distinguished. The depth of the first surface ranges from 15 to 40 km; the second ranges from 45 to 70 km. The maximum negative anomaly (-220 to -450 miligals) in the USSR was observed in this region. In Bouger's reduction this can be explained by relief of the deep boundaries.

STRUCTURE OF THE EARTH'S CRUST IN GEORGIA FROM GEOPHYSICAL EVIDENCE

B. K. Balavadze and G. K. Tvaltvadze; Review of Paper, XI Gen. Assem. Intern. Union Geod. & Geophys., Toronto, Sept. 1957; *Intern. Geol. Rev.* v. 1, No. 5:57-58; May 1959 (Soviet—In English).

Results of a seismometric and gravimetric study of the structure and physical properties of the layers composing the earth's crust in Georgia and adjoining regions of the Caucasus are discussed. The results show that the thickness of the crust in Georgia ranges from 40 to 67 km. The density of the various parts of the earth's crust, as well as the mean velocities of S and P waves, are included. Formulae are shown by which travel-time curves were drawn. (Longer English abstract available)

RELATIONSHIP BETWEEN BOUGUER ANOMALIES AND THE THICKNESS OF THE EARTH'S CRUST IN THE ATLANTIC OCEAN AREA

Ye. D. Koryakin, Moscow State Univ.; *Doklady Akad. Nauk SSSR* v. 129, No. 6:1287-1289; 1959. (In Russian)

In an oceanic area a relatively small change in the thickness of the earth's crust causes a noticeably greater change in gravitational anomalies than on the continents. The oceanic crust consists basically of basalt. As is evident in the case of the North Atlantic, even a small change in the thickness of this layer will cause a considerable change in the gravitational field in the oceans.

THICKNESS OF THE EARTH'S CRUST ALONG A MERIDIONAL PROFILE FROM THE DAVIS SEA TO PIONERSKAYA STATION

S. A. Ushakov and G. E. Lazarev, *Byulletin' Sovetskoy Antarkticheskoy Ekspeditsii* No. 10:9-12; 1959. (In Russian)

Data concerning the gravitational field and the thickness of the ice of Eastern Antarctic made it possible to compute Bouguer anomalies along this meridianal profile. It has been assumed that a zero Bouguer anomaly corresponds to a thickness of the earth's crust of 33 km. There is a gradual increase in the crustal thickness from the coast toward the heart of the continent. In the vicinity of Mirnyy it is about 32 km, at Pionerskaya—37 km, and at Komsomolskaya—about 40 km.

GEOPHYSICAL SOCIETY OF TULSA

TITLES AND ABSTRACTS OF PAPERS AND LECTURES

1959-1961

1. The Use of Acoustic Logs in the Evaluation of Sandstone Reservoirs

G. R. PICKETT, Shell Development Co.

October 8, 1959

Complete paper in Geophysics, V. 25, No. 1, pp 250-274.

2. Some Considerations of Lunar Shots

JAMES A. WESTPHAL, Sinclair Research Laboratories

October 8, 1959

3. The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer

November 24, 1959

(See No. G-3)

4. A Guide to the Determination of Seismic Reflection Quality and Its Relationship to Exploration Costs with Examples in West Texas and Southeast New Mexico

C. NEWTON PAGE, Continental Geophysical Co.

December 10, 1959

From study and analysis of many years of seismic records, a discussion of reflection quality and the effecting factors in the West Texas-Southeast New Mexico sedimentary province is presented. Reflection quality, seismic field technique and seismic exploration cost maps are presented to be used as a guide for geophysicists and exploration managers in planning forthcoming reflection seismic surveys within this broad area.

5. Elimination of Seismic Ghost Reflections by Means of a Linear Filter

J. P. LINDSEY, Phillips Petroleum Co.

January 14, 1960

A technique is described for elimination of ghost reflections on magnetically recorded seismograph records by means of a linear filter. The application of this filter does not alter the character of primary reflections although eliminating the ghost reflections. The principal assumption made in the development of the technique is that the effect of AGC in altering the amplitude ratio of primary and ghost reflections is uniform for all record time.

A realization of the required filter is given and a measurement technique is outlined for detecting the existence of ghost reflections based on the autocorrelation function of the seismograph trace.

Complete paper in Geophysics, V. 25, No. 1, pp 130-140.

6. Weight Dropping for Seismic Prospecting—The Geograph Method

W. H. REESE, Robert H. Ray Co., Inc.

February 11, 1960

The Geograph method for seismic prospecting began commercial operations in Edwards and Sutton Counties of West Texas in 1953. Today, there are more than 20 known weight dropping crews being used in oil exploration work. Although the initial impetus of this tool has been in problem areas, its use for fast reconnaissance surveys and for good record area detail work is increasing rapidly. The field techniques employed for good, fair, and poor record areas are shown, together with actual records obtained with each method. Of particular interest is the efficiency of the weight drop energy portrayed by a direct comparison of one weight drop versus 50 and 100 pounds of dynamite recorded with conventional equipment.

7. A New Magnetic Survey of the Owasso Dome

LEE LANAGAN, Varian Associates

March 10, 1960

A 15-minute movie describing the Varian Associates M-49 Portable Magnetometer, its unique principle of operation (nuclear free precession), and its use under a variety of field conditions, will be shown. A brief historical resume of ground magnetic field instrumentation is included in the movie.

The results of an M-49 survey conducted over the Owasso Dome, near Tulsa, will be compared to previous data collected at this locality. Former surveys include vertical and horizontal intensity ground magnetic data (which has been computed into a total intensity form and plotted) and airborne total intensity data (which has been reduced to the ground level).

8. Earth Crust Measurements by the Seismograph in Oklahoma

PAUL TUCKER, Humble Oil and Refining Co.
and
JAMES WESTPHAL, Sinclair Research Laboratories

March 10, 1960

Complete paper in this issue of *Proceedings*

9. Key to the Future of Geophysics, Improved Interpretation

T. O. HALL, General Geophysical Co.

April 14, 1960

The geophysical industry finds it necessary to reduce the geophysical cost for finding oil. This may be accomplished, first, by reducing operating costs; second, developing effective new tools and techniques, and third, by making better use of the data obtained by field parties. It is necessary to develop the geophysicist into an exploration specialist who can make the maximum use of the geophysical data and accomplish the fact of reducing the geophysical cost per barrel of oil found.

10. A Low Phase Distortion Seismic Amplifier

H. B. FERGUSON and J. J. ROARK, Jersey Production Research Co.

April 14, 1960

Phase distortion in an electrical network is a result of the individual frequencies in a signal being shifted by a different amount in phase or time. This results in skewing of a transient waveform as it passes through the network and introduces some uncertainty in the time pick of a seismic reflection. Phase distortion is present in all RLC networks, however, by proper design this distortion may be made arbitrarily small. A seismic amplifier with only a small amount of phase distortion will be described.

11. The Future of Oil in India

HARI NARAIN, Oil and Natural Gas Commission of the Government of India

April 25, 1960

12. The Interpretative Potential of Changes in Reflection Character

H. M THRALLS, Geo Prospectors, Inc.

May 12, 1960

Most of the undiscovered oil reservoirs in the U. S. can be assumed to be of low-relief, stratigraphic in nature, masked by mirrow-like reflecting surfaces, to underlie and terminate against unconformities or associated with abrupt changes in lithology. The seismograph in its present form lacks the resolving power to present most of these changes in anything other than composite form. Changes in composite form usually result in changes of so-called "Reflection Character."

The paper suggests a potential approach for seismic analysis of a specific geologic problem in a specific area through the medium of manufactured or synthetic records.

13. Well Logs and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.

October 13, 1960

(See C-18)

14. Studies of the Earth's Crust

C. H. DIX, California Institue of Technology

November 3, 1960

15. An Oil Man Looks at Russia

NEAL J. SMITH, Chevron Oil Co.

December 8, 1960

During the month of August, 1960, a delegation of eight oil-industry members chosen by the API and two from the Department of the Interior visited the USSR on the first technical exchange involving petroleum. The delegation traveled more than seven thousand miles within European-Russia

and adjacent Soviet Republics inspecting oil fields, refineries and production research facilities.

Complete paper in Geotimes, V. 5, No. 4, pp. 8-11, 38.

16. Convolution Filters

R. B. RICE

January 12, 1961

17. Metal Mining Exploration Techniques in the Air, on the Surface and Underground

A. A. BRANT, Newmont Exploration Ltd.

S.E.G. Distinguished Lecturer

February 9, 1961

18. Economics of Geophysics in Oil Exploration

PAUL L. LYONS, Sinclair Oil and Gas Co.

March 9, 1961

The economy of geophysical operations has changed and will continue to conform to an oil industry economy geared to an abundance of oil. Since geophysical exploration costs are primarily labor costs, the price of operations on a time basis has continued to rise. This is offset by a decrease in the cost of field work on a per mile basis, but it is augmented by necessary increases in the cost of processing and interpreting data. Overall, the cost of widespread coverage has been reduced considerably by the universal trading of data, affording inexpensive reviews of wide areas. Collectively, these trends reduce duplication of work and channel a reduced field effort into many limited surveys concerned with the detailing of prospects. This should result in a more stable employment of an optimum number of crews and a much higher success ratio for wildcat wells. A contrasting attack, curious because of the lack of competition, is indicated by reports of the Russians, who have announced the fielding of 650 seismic crews in the Soviet Union in 1960 and a goal of 1511 to be attained by 1965.

19. Statistics on Employment of Exploration Geophysicists

COLIN CAMPBELL, Society of Exploration Geophysicists

March 9, 1961

A total of 3,900 responded to a questionnaire sent to the 5,500 members of the Society of Exploration Geophysicists in December, 1960. Of these, 3,121 reside in the United States, 358 in Canada, 125 in Latin America, and 279 in the Eastern Hemisphere. They answered the following questions: Are you employed? seeking employment? a consultant? engaged primarily in geophysical work? If not, were you ever so engaged? Would you prefer full time geophysical work to your present activity? Grade of membership, location, education, length of experience, and industry or area of concern, were also furnished. Two hundred and twenty-two reported they were unemployed.

TITLES AND ABSTRACTS OF PAPERS AND LECTURES GIVEN BEFORE OTHER LOCAL GEOPHYSICAL SOCIETIES 1959-1961

A.

ARK-LA-TEX GEOPHYSICAL SOCIETY
Shreveport, Louisiana
(Chartered March 12, 1949)

A-1 A Survey of Seismic Playback Systems

T. O. HALL, President of S.E.G.
September 21, 1959

A-2 Gravity Anomalies Caused by Faults

RICHARD A. GEYER, Geophysical Service, Inc.
October 26, 1959

A-3 A Method for Obtaining Seismic Velocity Data Using Well Logs and Seismograms

STEWART MUT, The Atlantic Refining Co.
November 23, 1959

Abstract

There are several areas in which insufficient average velocity control hampers seismic exploration. In some areas, neutron logs and resistivity logs display a good correlation with the continuous velocity log. Synthetic seismograms completed from the neutron or resistivity log, in many cases, make possible the precise identification of one or more events recorded on a seismic record shot near the well. The time of the event is taken from the seismic record, the depth from the well log. After certain corrections are applied, the average velocity is calculated. The evidence suggests that one-way time-to-depth determinations good to ± 10 milliseconds are obtained in many cases.

A-4 Marine Seep Detection—A New Reconnaissance Method

T. F. MOORE, The Atlantic Refining Co.
January 25, 1960
(See G-1)

A-5 Recent Advances in Semiconductor Electronics

HOWARD E. SORROWS, Texas Instruments Inc.
February 29, 1960

A-6 Seismic Exploration in Mississippi

CHARLES W. NICHOLLS, Western Geophysical Co. of America
and
CHARLES P. BRAGG, Union Producing Co.
March 21, 1960

A-7 Uses and Abuses of Gravity

RICHARD A. GEYER, Geophysical Service, Inc.
September 26, 1960

A-8 Mistakes in Geophysics

H. M. THRALLS, Geo Prospectors, Inc.
October 31, 1960
(See D-5)

A-9 The Atlas Missile

Film, courtesy of Convair
November 28, 1960

A-10 Record Quality Improvement in Poor Record Areas

R. J. GRAEBNER, Geophysical Service, Inc.
January 30, 1961
Complete paper in Geophysics, V. 25, No. 1, pp. 283-311.

A-11 Earth Crust Measurements by the Seismograph in Oklahoma

P. M. TUCKER, Humble Oil and Refining Co.
February 27, 1961

Abstract

Utilizing a large quarry blast, the GST Earth Crust Study group made their first seismic recordings on a profile setup 26 miles from the blast. Many energy bursts were recorded from various blasts at this location suggesting both refraction and reflection energy; one at 15 seconds was tentatively identified as a reflection from the Mohorovicic Discontinuity. A second profile 5 miles in length was shot north from the quarry. An energy burst recorded at 5 seconds was tentatively identified as from the Conrad Discontinuity. The third profile, eighteen miles in length, was shot south of Tulsa using dynamite as a sound source. Noise level studies here showed that nominal dynamite charges would suffice provided atmospheric wind velocity was less than 5 miles per hour. This set-up repeated the so-called Conrad and Mohorovicic reflections.

These experiments have shown that either large quarry blasts or relatively small dynamic charges are equally good for recording deep seated reflections. Communication between source and spread may be made by Bell Telephone, radio, or indirectly by WWV time signals. It would appear that setting up at the critical angle may be helpful in recording reflections. The number of energy bursts recorded suggests a layering in the crust not heretofore suspected.

Our future plans are to continue these profiles, first over a large local gravity anomaly and eventually across a major geological feature.

A-12 The Future of Geophysics

J. P. WOODS, President of S.E.G.
March 27, 1961

A-13 An Oil Man Looks at the U.S.S.R.

NEAL J. SMITH, Chevron Oil Co.
April 24, 1961
(See No. 15)

B.

ASOCIACION VENEZUELA DE GEOFISICIA
Caracas, Venezuela
(Chartered January 5, 1959)

B-1 Exploration Activities in the Middle-East and Exploration in Egypt

Film presentation
August 17, 1959

B-2 Magnetic Tape Field Recording Systems

R. A. KIRBY, Jersey Production Research Co.
August 25, 1959

During the past several years there has been a tremendous increase in the use of magnetic tape recording by the geophysical industry. Seismic field recording instruments have been converted almost one hundred per cent to magnetic tape recording of some type. At the present time eight companies are offering fifteen different models.

There are two fundamental differences in magnetic recorders. One is the system of recording the information in the tape (direct or bias modulation; frequency modulation and pulse-width modulation). The other is the method of moving the tape by the recording heads (belt, drum and disc). Each of these systems has its respective advantages and disadvantages.

A discussion of these different systems together with the tabulated characteristics of the available field recorders is presented.

B-3 The Sinclair Dip Plotter

B. G. BAUGH, Seismograph Service Corp. of Venezuela
December 7, 1959

An electro-mechanical device has been designed by Sinclair Research Laboratories which will migrate data from seismic records to migrated cross sections without intermediate processing or calculation. For convenience in design and operation, the machine plots in polar coordinates according to velocity functions which are linear with depth. Certain assumptions have been made which are acceptable within the limits for which the machine was de-

signed. These assumptions are compared with the linear increase in velocity with depth formulae which they approximate and an operational procedure is suggested to improve the approximation.

B-4 Use of Electronic Computers in the Solution of Geophysical Problems

W. F. CLARK, Mene Grande Oil Co.

January 25, 1960

B-5 An Evaluation of Basement Depth Determinations from Airborne Magnetometer Data

P. JACOBSEN, Creole Petroleum Corp.

March 14, 1960

Three years ago Creole submitted airborne magnetometer data for a portion of the Eastern Venezuela basin to two different geophysical contractors for independent, detailed analysis. These contractors offer the customary generalized basement depth maps; but they specialize in delineating areas of relatively local relief on the basement surface, and both kinds of interpretation were requested by Creole.

The main purpose of the study was to evaluate the reliability of interpretations of local basement relief from magnetic data. Accordingly, the study was deliberately chosen to include, in part, areas for which we had considerable knowledge of basement depths and local basement configuration from other sources. The two contractor interpretations are compared with a generalized basement depth map based on seismograph and well information.

Some tentative conclusions are drawn as to the reliability and usefulness, or not, of basement depth maps obtainable from detailed analysis of magnetic data by experienced and reputable contractors.

Complete paper in Geophysics, V. 26, No. 3, pp. 309-319.

B-6 Outline of World Geology and the Development of Mountain Systems

J. TUZO WILSON, University of Toronto

March 28, 1960

B-7 Visit to the Observatorio de Caracas

DR. JOSE ABDALA and DR. GUNTHER FIEDLER,
Geomagnetic and Seismological Institutes

July 11, 1960

C.

CANADIAN SOCIETY OF EXPLORATION GEOPHYSICISTS

Calgary, Alberta

(Chartered January 24, 1952)

C-1 I.G.Y. Review

D. C. ROSE, National Research Council of Canada

September 21, 1959

C-2 Effect of Subsurface Layering on Wave Forms

R. A. PETERSON, United Geophysical Co.
October 22, ,1959

Velocity Logging Symposium

November 19, 1959

C-3 Applications to Seismic Interpretation

W. G. RIMMER, Triad Oil Co.
November 19, 1959

C-4 Discrepancies Between Conventional Surveys and Continuous Velocity Logs

P. E. GRETENER, Shell Oil Co. of Canada, Ltd.
November 19, 1959
Complete paper in Geophysics, V. 26, No. 1, pp. 1-11.

C-5 Effect of Spacing Mud Velocities and Wave Paths on Velocity Logs

J. FERGUSON, Seismograph Service Corp.
November 19, 1959

C-6 Collection and Processing of Digitized Acoustic Log Data

R. A. BRODING and J. L. POOLE, Century Geophysical Corp.
November 19, 1959
Complete paper in Geophysics, V. 25, No. 4, pp. 939-947.

C-7 Datum Corrections in Glacial Drift

A. R. PATTERSON, Exploration Consultants Inc.
December 3, 1959

C-8 A Direct Method for Removing Diurnal Variations from Airborne Magnetometer Profiles

H. WAYNE HOYLMAN, Consultant
January 18, 1960

C-9 Drilling the Mohole

WILLARD BASCOM, A.M.S.O.C.
February 5, 1960
(See No. G-3)

Annual Meeting

February 18, 1960

C-10 Key to the Future of Geophysics—Improved Interpretation

T. O. HALL, General Geophysical Co.
(See No. 9)

C-11 S.E.G. Affairs

FRANK SEARCY, Continental Oil Co.

C-12 Exploration Coordination, Souris Valley Area

D. H. PARRY, Imperial Oil Ltd.

C-13 Record Quality Improvement in Poor Reflection Areas

R. J. GRAEBNER, Geophysical Service International, Inc.
March 8, 1960
(See No. A-10)

C-14 The Physical Optics of Seismic Waves

LEON KNOPOFF, University of California at Los Angeles
April 25, 1960

C-15 Physical Properties of Water Saturated Sediments

JOHN E. NAFE, Lamont Geological Observatory, Columbia University
May 9, 1960

C-16 The Role of Geophysics in the Search for Oil in Western Canada

H. J. McGREW, British American Oil Co., Ltd.
June 23, 1960

C-17 Intra-Basement Reflections in Southwestern Alberta

G. ROBERTSON, Shell Oil Co.
Presented by J. J. HAMILTON, Shell Oil Co. of Canada, Ltd.
June 23, 1960

C-18 Magnetic Tape and Well Logs

J. P. WOODS, The Atlantic Refining Co.
September 7, 1960

Well logs can easily be recorded on magnetic tape. Present logs can be transcribed on to tape, or the logs can be written on tape at the wellsite. Twenty or more curves can be written on a single tape, and each curve can have an amplitude range as great as one hundred. Once recorded on tape, logs can be played back to various scales and amplitudes. The log of an inclined hole can be corrected to vertical. A log recorded in depth can be played back in seismic time. A log can be filtered to produce a synthetic seismogram. Logs can be filtered to aid in the correlation process. Finally, logs on tape can be fed into computing machines which make correlations by a mathematical process.

C-19 Seismic Distortion Problems

W. R. MITCHELL, National Geophysical Co.
September 20, 1960
(See No. T-12)

C-20 An Oil Man Looks at the U.S.S.R.

NEAL J. SMITH, Chevron Oil Co.
October 3, 1960
(See No. 15)

C-21 The Aurora Borealis

B. W. CURRIE, University of Saskatchewan
October 25, 1960

Public Meeting sponsored by Canadian Society of Exploration Geophysicists, Alberta Society of Petroleum Geologists, Canadian Well Logging Society, and Institute of Radio Engineers.

October 25, 1960

C-22 Activities of the University of Alberta in Calgary

B. G. WILSON, University of Alberta
November 21, 1960

C-23 Magnetic Pulsations and Their Applications in Exploration

KEEVA VOZOFF, University of Alberta
November 21, 1960

C-24 Fault Motion as Determined by Earthquake Seismographs

A. E. SCHEIDEGGER, Imperial Oil, Ltd.
December 8, 1960

C-25 Interval Velocity from Reflection Data

ARNE JUNGER, Shell Oil Co. of Canada, Ltd.
January 26, 1961

C-26 Recording of the Suffield Air Blast

A. MUIR
January 26, 1961

C-27 Pattern for Staying Alive

A film presentation
January 26, 1961

C-28 The Role of Geophysics in the Geological Survey of Canada

GEORGE D. HOBSON, Geological Survey of Canada
March 29, 1961

C-29 A Seismic Survey in the Papuan Jungle

M. B. DOBRIN
April 27, 1961

C-30 Gravity and Magnetics for Seismologists and Geologists

L. L. NETTLETON, Geophysical Associates International

May 23, 1961

(See No. W-2)

C-31 Effects of Muskeg on Reflection Quality

S. N. DOMENICO and O. J. GROSS, Pan American Petroleum Corp.

June 20, 1961

C-32 Relation Between Signal-to-Noise Ratio and Visual Improvement of Seismic Records

ARNE JUNGER, Shell Oil Co. of Canada, Ltd.

June 20, 1961

D.

CASPER GEOPHYSICAL SOCIETY

Casper, Wyoming

(Chartered May 23, 1953)

D-1 The Continuous Velocity Log

H. W. HARDY, Humble Oil and Refining Co.

September 22, 1959

The Petroleum Industry's increasing acceptance of the continuous velocity log as an aid in geological, production and geophysical operations provides evidence of this new tool's diversity.

The basic requirement of instrumentation and presentation is the capability of measuring sound travel time across a finite portion of a borehole wall, and presenting it in a usable form. The instrumentation of all the systems currently in use is very similar. Several methods of recording are currently being used by the various companies which provide velocity logging services.

Use of the continuous velocity log with adequate check shots makes it an outstanding source of vertical time, interval velocity, and average velocity information in support of geophysical exploration activities. The recognition and definition of the relation between velocity and porosity has caused this log to become popular with geologists as a qualitative and quantitative analysis tool as well as a correlation log. This capability coupled with its power of resolution produced by the high sampling rate and short spacing lends itself naturally to problems encountered by production personnel in reservoir engineering.

In the relatively brief period of time in which commercial velocity logging services have been available, this technique has reached a position of industry-wide acceptance equaling that obtained by electrical logging only after 15 years of sales promotion.

D-2 How Thin is a Thin Bed?

M. B. WIDESS, Pan American Petroleum Corp.

October 1, 1959

The effects of bed thickness on reflection character, timing, and amplitude are described quantitatively. On the basis of these properties, a thin bed may be conveniently defined as one whose thickness is less than about $a_b/8$, where a_b is the (predominant) wave length computed using the velocity of the bed. The amplitude of a reflection from a thin bed is to the first order of approximation equal to $4 \pi Ab/a_b$, where b is the thickness of the bed and A is the amplitude of the reflection if the bed were to be very thick. The equation shows that a bed as thin as 10 ft. has, for typical frequency and velocity, considerably more reflective power than is usually attributed to it.

In general, the reflective properties of thin beds can be perceived from elementary considerations, and the aura of mystery that has prevailed over the thin beds is unnecessary.

Complete paper in Proceedings of the Geophysical Society of Tulsa, vol. 5, pp. 17-22, 1957-58.

D-3 What is a Good Geophysicist?

J. F. PARTRIDGE, Consulting Geologist-Geophysicist

November 2, 1959

What is a good geophysicist—or perhaps more appropriately for our interests—a good exploration geophysicist? The qualities necessary to a geophysicist are analyzed first from the "geo" or earth side and then from the "physics" side. The training, experience, and mental attitude necessary to a geophysicist are outlined. The application to exploration is then discussed. The roles of geophysicists, geologists, and explorationists are then outlined and the coordinated effort between them necessary to successful exploration is reviewed. With this background the good geophysicist is then defined.

A second part of the paper deals with the future of the geophysicist. Particular emphasis is placed on the geophysicists role in domestic exploration. The problems to be faced in the Rocky Mountain Area and Wyoming in particular are summarized.

D-4 Computer Applications in the Petroleum Industry

BERT GOLDBERG, International Business Machines Corp.

December 14, 1959

D-5 Mistakes in Geophysical Prospecting

H. M. THRALLS, Geo Prospectors, Inc.

January 12, 1960

Geophysicists, as a professional group, must have made some severe mistakes; otherwise, they would occupy a much stronger position in the economic world than they do today. Errors can be broken down into four main divisions:

(a) economics of instrumentation; (b) economics of field application; (c) interpretation; and (d) salesmanship.

Discussion of any one of the four divisions will involve an overlap into the others. Most of the material in this paper is devoted to Item C, or "Interpretation," although it is inevitably associated with Items A and B, and loosely related to Item D.

All who have survived the economic ax and remained in the seismograph business for twenty-five years have enjoyed blissful moments of success and praise, and have suffered through many more periods of castigation resulting from their mistakes. Some of the author's greatest blunders and biggest "busts" have been the result of recommendations based on very flimsy evidence. Both type experiences have occurred so many times that the author never feels good about a drill prospect, unless it is so poorly substantiated that he's "scared to death" of it.

An analysis of those "positive interpretations" which are proved incorrect by the drill, leads to the inevitable conclusion that we still know far too little about the factors which contribute to what we described as a reflection. If we can see something good when it isn't there, how often have we seen nothing when a good oil prospect is there?

The CVL and sonic logs provide some basic information and some raw material for study of reflection composition which we didn't have a few years ago. Examples of mistakes in seismic interpretation given in the paper are illustrated and analyzed by a synthetic seismic record approach using velocity logs as a starting point.

D-6 Key to the Future of Geophysics, Improved Interpretation

T. O. HALL, President of S.E.G.
February 25, 1960
(See No. 9)

D-7 Current Projects of the S.E.G.

FRANK SEARCY, First Vice-President of S.E.G.
February 25, 1960

D-8 Percentage Depletion and What It Means to the Oil Industry

JACK BAILEY, Gulf Oil Corp.
March 10, 1960

D-9 Stratigraphy versus Noise

CARL H. SAVIT, Western Geophysical Co. of America
April 7, 1960

Stratigraphic information is inherently present in seismic reflection signals. Noise ordinarily prevents our seeing reflections in unprocessed signals. Processing of signals to remove noise, unfortunately, also removes the stratigraphic information.

New developments in instrumentation and a new understanding of the interrelationships of seismic signals and seismic noise lead to a philosophy of data treatment which promises to preserve stratigraphic information. Seismic information obtained for stratigraphic purposes will, in the future, be recorded wtihout AVC and will be freed from noise by mixing instead of by filtering. In this way, reflection "character" will be preserved for correlation with stratigraphy.

D-10 The Tehachapi Earth Quake of 1952

B. A. TULLER, Pan American Petroleum Corp.
May 9, 1960

D-11 The Terrestial Theory of the Ice Age

WILLIAM L. DONN, AAPG Distinguished Lecturer
June 2, 1960
Joint meeting with Wyoming Geological Association
(See No. T-15)

D-12 Case History of the Desert Springs Gas Field

JOHN H. EARL, El Paso Natural Gas Co.
September 12, 1960

D-13 Citizen First—Business Man After

ELMER S. PARSON, Continental Oil Co.
October 10, 1960

D-14 Case History of a Failure—Dickinson Area, North Dakota

HUGH McCAIN, The Atlantic Refining Co.
November 17, 1960

D-15 Some Aspects of Refraction Interpretation

M. E. TROSTLE, Geophysical Service, Inc.
January 9, 1961
(See No. W-1)

E.

COASTAL BEND GEOPHYSICAL SOCIETY
Corpus Christi, Texas
(Chartered May 29, 1959)

E-1 Geophysical Work in Alaska

JOHN R. WOOLSON, United Geophysical Co.
September 8, 1959

Northern Alaska is separated from the remainder of the 49th state by the Brooks Mountain Range. It is the approximate northern one-third of the state and an area of about 70,000 square miles with which this paper is concerned. It is divided into two administrative units with about 37,000 square miles in the Naval Petroleum Reserve No. 4 and 33,000 square miles under the Bureau of Public Lands.

Structurally, the area is a single asymmetric basin similar in general structural aspect to the Denver-Julesberg basin and the Alberta Basin. The principal sedimentary rocks of the basin are Cretaceous which thicken from about 2,000 feet in the north to 20,000 feet or more in the south. Lithologically, the Cretaceous consists of a shallow sand-shale sequence about 3,000 feet thick (the upper Cretaceous) and an underlying shale (the lower Cretaceous) which thickens from north to south. The Brooks range is a complex of thrust faults and related folds in the pre-Cretaceous. The effect of this thrusting is a series of elongate east-west trending diapir folds in the Cretaceous which extended about 100 miles north of the mountain front.

As a result of the Navy's exploration program, oil and/or gas was discovered at Barrow, Simpson, Umiat, Gubik and Fish Creek. None of these wells developed commercial quantities of oil but they do indicate the area is a potential petroleum province.

The principal objective horizon would seem to be the Mississippian-Lisburne limestone which is about 2,000 feet thick in outcrop and has some outcrop seeps and a petroliferous odor in fresh fracture. It was missing in the test wells drilled in the northern part of the area near Point Barrow. It should occur in major thrust folds near the mountain front, such a fold is interpreted at Carbon Creek anticline, a surface structure which can be followed for about 100 miles in an east-west direction. The Lisburne was not drilled into during the course of the 1945 to 1953 exploration program.

Seismic results in the area were generally good and checked both the drilling and surface geology after being corrected for velocity variation. Gravity results seem to be useful to define structure in the higher density pre-Cretaceous. There is, for example, a gravity definition of the Carbon Creek thrust fold and a pre-Cretaceous cryptovolcanic structure near Point Barrow. The airborne magnetometer results do not seem to be useful to define structure in the sedimentary section.

Operation and support problems are, of course, complicated by remoteness and an inhospitable climate. These problems have been solved and costs were not materially different from any other "foreign" area. Although an extensive exploration program was conducted; it was quite limited relative to the size of the area. It would seem that the exploration program reached the stage of knowing what needed doing.

E-2 Comparison of Well Velocity Methods in South Texas

ARTHUR WOOD, Shell Oil Co.

October 13, 1959

Complete paper in Geophysics, V. 24, No. 3, pp. 443-450.

E-3 Current Major Factors in Oil Exploration

EDGAR W. OWEN, Consulting Geologist
November 10, 1959

E-4 Weight Dropping for Seismic Prospecting—The Geograph Method

WYMAN H. REESE, Robert H. Ray Co., Inc.
December 8, 1959
(See No. 6)

E-5 Key to the Future of Geophysics—Improved Interpretation

T. O. HALL, President of S.E.G.
January 12, 1960
(See No. 9)

E-6 Magnetic Tape Recording

DEAN MILLER, Humble Oil and Refining Co.
February 9, 1960

E-7 How Fast Does a Salt Dome Grow?

PAUL WEAVER, Texas A. and M. College
March 8, 1960

E-8 Economic Evaluation of Wildcat Prospects

ALAN LOHSE, Consulting Geologist
April 12, 1960

E-9 A Terrestial Theory of Ice Ages

WILLIAM L. DONN, Lamont Geological Observatory, Columbia University
June 9, 1960

Joint meeting of Corpus Christi Geological Society and Coastal Bend Geophysical Society.

(See No. T-15)

E-10 Uses and Abuses of Gravity

R. A. GEYER, Geophysical Service, Inc.
September 19, 1960

E-11 World Oil Situation

W. J. GOLDSTON, Mid-Continent Oil and Gas Association
October 17, 1960

E-12 Role of Concurrent Deposition and Deformation of Sediments of Salt Dome Graben Structures

Film by Gulf Research and Development Co.
November 21, 1960

E-13 A Crustal Structure Refraction Survey in East and South Texas

IRA CRAM, JR.
January 16, 1961

E-14 Gravity and Magnetics for Geologists and Seismologists

L. L. NETTLETON, Geophysical Associates International
February, 1961
(See No. W-2)

E-15 Depositional Topography

DeWITT VAN SICLEN
March 1, 1961

Joint meeting of Corpus Christi Geological Society and Coastal Bend Geophysical Society.

E-16 Future of Exploration

J. P. WOODS, President of S.E.G.
March 20, 1961

F.

COCHABAMBA GEOPHYSICAL SOCIETY
Cochabamba, Bolivia
(Chartered May 4, 1959)

G.

DALLAS GEOPHYSICAL SOCIETY
Dallas, Texas
(Chartered August 7, 1948)

G-1 Marine Seep Detection, a New Reconnaissance Exploration Method

HENRY C. DUNLAP, JOHN S. BRADLEY, and TOM F. MOORE,
The Atlantic Refining Co.
September 21, 1959

A large number of major oil accumulations of the world are associated with oil or gas seeps. At the least, seeps prove the existence of mobile hydrocarbons in a basin. At the most, and when used with other geological and geophysical data, they can aid in locating exploratory wells.

An effective and inexpensive instrumental technique for locating gas seeps has been developed for use in water covered areas. If a seep is present, some of the methane dissolves in the water as the gas bubbles rise to the surface. Currents spread this methane-enriched water into a long plume. A boat samples the water continuously, operating over a grid laid out at right angles to the current. The gas dissolved in the water is broken out of solution,

and trace concentrations of methane detected using an infrared analyzer. This equipment has detected seeps at distances as great as six miles. A novel system of location using navigational radar is used in carrying out the survey.

Several marine seeps surveys have been carried out using equipment monuted on various vessels ranging in size from a 14-foot outboard powered skiff to a coastwise freighter. Under most circumstances, the cost of the survey is a few cents per acre. In new basins, the method promises to be of considerable value in localizing areas of interest for more expensive exploration methods.

Complete paper in Geophysics, V. 25, No. 1, pp. 275-282.

G-2 Public Secondary Education

JAMES R. KILLIAN, formerly Special Assistant for Science and Technology to President Eisenhower

October 22, 1959

Sponsored by the Council of Scientific Societies

G-3 The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer

November 19, 1959

Man is the most curious of all animals. He rides a spinning sphere through space, all the time wondering where it came from, how old it is, what it is made of, and how life developed. Partial answers to these questions lie buried in the sediments of the deep sea floor, in the rocks of deep crust and in the mantle itself. Indirect methods of exploring the deep rocks have gone about as far as they can go. Therefore the AMSOC Committee of the National Academy of Sciences is preparing to drill a hole completely through the crust of the earth beneath the ocean to obtain continuous oriented cores of the crust and the rim of the mantle.

The boundary between the earth's crust and mantle was defined by Professor A. Mohorovicic in 1910 as a discontinuity at which the velocity of seismic waves increased abruptly. In his honor it is commonly known as the Moho and so a bore hole to the mantle is logically called the Mohole. It will be the culmination of a project in which a series of experimental holes will be drilled for various scientific purposes.

The oceanic crust is much thinner than the continental crust and the AMSOC Committee believes that if the best of modern drilling equipment is installed on a ship, the mantle can be reached. There are several places where the Moho comes within about 31,000 feet of the sea surface—only 20% deeper than the deepest oil well.

Geophysical surveys of several sites are underway to determine oceanic currents and the depths to the various layers. Plans for holding a ship in position in deep water, for coring both very soft and very hard sediments, for precisely orienting logs and cores and for modifying a ship to do deep drilling

are now being made. It is hoped that some preliminary test holes can be made in the soft sediment with some existing drilling ship by the summer of 1960. The extensive remodelling of a ship for deep drilling may begin about the same time.

We believe that this program can be carried out and that the result will be a great stride forward for the science of geology-geophysics.

G-4 Extinction at the End of the Triassic

EDWIN H. COLBERT, American Museum of Natural History

December 8, 1959

G-5 A New Marine Seismic System

FRANK J. McDONAL, G. B. LOPER, C. D. McCLURE, and
E. B. SIMPSON, Socony Mobil Field Research Laboratory

January 18, 1960

From a practical point of view, one of the most important problems facing geophysicists today is the high cost of seismic exploration. The system described here was developed with the objective of obtaining useful seismic data at a significant reduction in cost. The method is a one-boat operation which employs a detonation gun as a source of seismic energy for obtaining variable-density records in a repetitive manner as the boat moves at a uniform speed. In the Gulf of Mexico and in the bays along the coast, records consistantly show good reflections from depths of 4000-5000 feet, and in some areas reflections from 8,000 feet or more. The source of energy is a detonation gun 20 feet long and 6 inches in diameter, which is fed a fuel mixture of propane and air, or propane, air, and oxygen. A spark plug initiates a detonation of the fuel which develops a shock wave that strikes the water at the submerged end of the gun. Seismic signals from a line of pressure detectors towed behind the boat are fed to a conventional seismic amplifier and thence to a magnetic-drum compositor. Each shot is recorded on the magnetic drum, and the sum of two or more channels (up to a maximum of 16) are added for output to variable density and magnetic tape recorders. Electro-sensitive paper is employed for the variable density section since this permits viewing the signals as they are recorded. The section is then a series of 3.0 sec. seismic records across 18-inch paper, with variable density traces spaced 1/64 inch to give the appearance of a continuous section. A standard high-fidelity stereo magnetic tape recorder records the output of the magnetic drum compositor or the uncomposited signals direct from the input seismic amplifier. These are played back as conventional seismic records or as variable-area or variable-density records sections with the filtering and compositing of the operator's choice. Slides illustrate typical variable density sections across structures in the Gulf of Mexico.

G-6 Interpretation of Synthetic Seismograms

R. L. SENGBUSH, P. L. LAWRENCE, and F. J. McDONAL,
Socony Mobil Field Research Laboratory

February 15, 1960

In the seismic process a shot pulse travels in the earth producing reflections which are recorded as a field record. Synthetic seismograms are made by filtering a modified continuous-velocity log using ordinary seismic filters. The question arises as to why we should expect the two records to match when they come from such dissimilar processes. However, there is a common denominator in that both are filter processes. In the seismic process a shot pulse input is sent into a complicated black box known as the earth and the reflection record is the output from this black box. In making synthetic seismograms this process is simplified by assuming that (1) the layering of the earth is described by the velocity layering as measured using a continuous velocity log, (2) the shot pulse waveform does not change as it travels through the earth, and (3) all multiples, ghosts, and noise are negligible. One may expect good correlation between the synthetic and field records if these assumptions are valid. Synthetic seismograms show the relation of the velocity layering, the field seismogram, and the shot pulse waveform. Thin beds produce a differentiated shot pulse, beds which approximate a square wave produce a pair of shot pulses, with the second delayed in time and reversed in phase. The composite reflection has its greatest amplitude when the layer thickness (two-way travel time) is one-half the basic period of the shot pulse. This situation is calling "tuning." The strongest reflections on field records result when the velocity layering is tuned to the shot pulse. Since each interface (each point in depth) produces a reflection of finite length, a unique one-to-one correspondence cannot be established between the velocity function and a reflection record. However, such a correspondence can be established if a given depth point in the velocity function is made equivalent by definition to a given time point on the reflection record. All other depth points then have a unique time point on the reflection record. Three examples of synthetic seismograms are included to illustrate the correlation of field records and velocity logs, and to point out the effects of tuned layers, thin beds, and ramp and step reflections.

Complete paper in Geophysics, V. 26, No. 2, pp. 138-157.

G-7 Magnetic Tapes and Well Logs

J. P. WOODS, The Atlantic Refining Co.

March 14, 1960

(See C-18)

G-8 The Future Course of United States Exploration

R. S. ENRIGHT, Oil and Gas Journal

April 11, 1960

G-9 A Terrestrial Theory of Ice Ages

WILLIAM L. DONN, Lamont Geophysical Observatory, Columbia University

May 26, 1960

Joint meeting with the Dallas Geological Society

(See No. T-15)

G-10 Application of Refraction to the Delaware Basin

M. E. TROSTLE, Geophysical Service, Inc.
September 27, 1960
Complete paper in Proc. Geoph. Soc. Tulsa, V. 4, pp. 34-42.

G-11 Project Cowboy

LARRY STRICKLAND, Texas Instruments, Inc.
October 17, 1960

G-12 Wave Front Charts and Three Dimensional Migrations

A. W. MUSGRAVE, Mobil Oil Co.
November 21, 1960

G-13 The Use of Computers in Well Log Analysis

R. A. BRODING, Century Geophysical Corp.
December 5, 1960

G-14 Exploration with Processed Data

R. G. HAMILTON, Hamilton Well Log Consultants
December 5, 1960

G-15 Geology and Geophysics in Russia

NEAL J. SMITH, Chevron Oil Co.
December 20, 1960

G-16 Renewed Activity of the Volcano Anak Krakatau

ROBERT W. DECKER, Dartmouth College
January 31, 1961
Joint meeting with the Dallas Geological Society

G-17 Mining Geophysics

A. A. BRANT, S.E.G. Distinguished Lecturer
February 13, 1961

H.

DENVER GEOPHYSICAL SOCIETY
Denver, Colorado
(Chartered May 19, 1950)

H-1 Use of Acoustic Logs in the Evaluation of Sandstone Reservoirs

G. R. PICKETT, Shell Development Co.
September 14, 1959
(See No. 1)

H-2 Synthetic Seismograms: Their Construction and Application to Interpretation

LEONARD LARGUIER, Consulting Geophysicist

October 5, 1959

Interpretation of pinchout and stratigraphic changes from seismic records has always been desired. Now, better and more detailed knowledge of seismic velocities resulting from continuous velocity logs make possible better understanding of the elements of the traces on a seismic record. Construction and study of synthetic seismograms, made either from continuous velocity logs or from electric logs, now lead to the possibility of pinchout and stratigraphic interpretation as well as to the improvement of conventional structural interpretation.

H-3 Technique for Improving Seismic Interpretations

R. W. MOSSMAN, Seismograph Service Corp.

November 2, 1959

A more complete and accurate interpretation of seismic data can be obtained through use of modern recording, display, and analysis techniques. These new methods provide greater stratigraphic and structural information and better evaluation of unwanted energy. Specific examples were shown.

H-4 The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer

November 16, 1959

(See No. G-3)

H-5 Creativity versus Difficulties in Exploration

JOHN M. CRAWFORD, Continental Oil Co.

January 11, 1960

H-6 Stratigraphy versus Noise

CARL H. SAVIT, Western Geophysical Co. of America

April 6, 1960

(See No. D-9)

H-7 A Terrestrial Theory of Ice Ages

WILLIAM L. DONN, A.A.P.G. Distinguished Lecturer

June 6, 1960

Joint meeting with Rocky Mountain Association of Geologists

(See No. T-15)

H-8 Case History of the Desert Springs Gas Field, Sweetwater County, Wyoming

JOHN H. EARL, El Paso Natural Gas Co.

September 13, 1960

H-9 Blasting Vibration—Cause and Effects

Film by Hercules Powder Co.
October 11, 1960

H-10 Changes in Crustal Temperature Due to Sedimentation

FRANK A. HADSELL, Colorado School of Mines
November 15, 1960

H-11 Metal Mining and Exploration

A. A. BRANT, S.E.G. Distinguished Lecturer
December 5, 1960

H-12 Some Aspects of Refraction Interpretation

M. E. TROSTLE, Geophysical Service, Inc.
January 10, 1961
(See No. W-1)

H-13 Vibroseis

MILFORD LEE, Continental Oil Co.
April 11, 1961

H-14 Gravity and Magnetics for Seismologist and Geologist

L. L. NETTLETON, Geophysical Associates International
May 2, 1961

H-15 Geological Effects of the 1959 Earthquakes in Yellowstone National Park

WILLIAM A. FISHER, Colorado College
May 8, 1961

K.

FORT WORTH GEOPHYSICAL SOCIETY
Fort Worth, Texas
(Chartered August 7, 1948)

K-1 The Oil Man's Prophet

Film shown by JERRY CAHILL, Welex, Inc.
July, 1959

K-2 Evaluation, Handling and Storage of Magnetic Tapes

ROBERT B. FISHER, Davis Equipment Co.
August, 1959

Although many technical papers have been prepared covering the theory and operation of magnetic recording equipment as a useful method of storing

and processing geophysical field data, information regarding the recording media or the tape itself has heretofore been discussed only briefly.

A brief historical background of magnetic recording and an explanation of magnetic theory and terminology is given. The characteristics of magnetic oxides and backing materials in common use in the geophysical industry are presented. The effects on recorded signals of pinholes, nodules, and other tape defects are analyzed. The proper methods of handling, shipping, and storing of magnetic recording materials are explained.

K-3 Interesting Aspects of Space Flight

W. A. ORR, Convair Division of General Dynamics

September 28, 1959

K-4 Talk by Congressman Jim Wright

October 20, 1959

Joint meeting of Fort Worth Geophysical Society, Fort Worth Geological Society and AIME.

K-5 Trap Barriers—Hydrodynamic, Stratigraphic and Wettability

GILLMAN HILL, A.A.P.G. Distinguished Lecturer

October 27, 1959

Joint meeting Fort Worth Geological Society

K-6 The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer

November 20, 1959

(See No. G-3)

K-7 The Earth's Changing Climates

ERLING DORF, A.A.P.G. Distinguished Lecturer

January 19, 1960

K-8 Blasting Vibrations—Cause and Effect

Film by Hercules Powder Co.

February 29, 1960

K-9 Well Logging and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.

March 28, 1960

(See No. C-18)

K-10 The World Surplus, and How to Live with It

EDWARD SYMONDS, First National City Bank of New York

April 28, 1960

Joint meeting with Fort Worth Geological Society, A.I.M.E., Petroleum Accountants and Landmen.

K-11 A Terrestrial Theory of the Ice Ages

WILLIAM L. DONN, A.A.P.G. and S.E.G. Distinguished Lecturer
June, 1960
(See No. T-15)

K-12 Exploration in Panama

Film by Champlin Oil and Refining Co.
July 25, 1960

K-13 The Atlas Missile

Film by Convair Division of General Dynamics
August 29, 1960

K-14 Football Highlights of the Southwest Conference in 1959

Film by Humble Oil and Refining Co.
September 12, 1960

K-15 The Future of Geophysics

J. P. WOODS, President of S.E.G.
November 28, 1960

K-16 The Renewed Activity of the Volcano Anak Krakatau

ROBERT W. DECKER, Dartmouth College
January 31, 1961
Joint meeting with Fort Worth Geological Society

K-17 Metal Mining Exploration Techniques

A. A. BRANT, S.E.G. Distinguished Lecturer
February 13, 1961

K-18 Some Aspects of the Generation of Harmonic Distortion in a Seismic System

W. R. MITCHELL, National Geophysical Co.
March 27, 1961
(See No. T-12)

K-19 Visual Tracking of Artificial Earth Satellites

HERMAN SCHESTED
April 18, 1961
Joint meeting with Fort Worth Geological Society

L.

FOUR CORNERS GEOPHYSICAL SOCIETY
Durango, Colorado
(Chartered June 19, 1958)

L-1 Manufacture of Commercial Explosives and Plant Safety

Mr. JENSEN, Atlas Powder Co.
September, 1959

L-2 A One Hundred Year Forecast of the World Energy and Oil Requirements

L. G. WEEKS, President of A.A.P.G.
October 10, 1959

L-3 Cretaceous and Jurassic Hydrodynamics and Geochemistry of the San Juan Basin

FREDERICK A. F. BERRY
November 11, 1959
Joint meeting with Four Corners Geological Society

L-4 Uses and Abuses of Gravity

R. A. GEYER, Geophysical Service, Inc.
December 10, 1959

L-5 Key to the Future of Geophysics—Improved Interpretation

T. O. HALL, President of S.E.G.
February 29, 1960
(See No. 9)

L-6 Conquering Ripple Rock

Film by du Pont de Nemours and Co.
March 10, 1960

L-7 Current Affairs of the National Society

FRANK SEARCY, First Vice-President of S.E.G.
April 22, 1960

L-8 Creativity versus Exploration Problems

JOHN M. CRAWFORD, Continental Oil Co.
April 22, 1960

L-9 Current and Future Parameters in Geophysics

RICHARD BAILE, Empire Geophysical Co.
May 27, 1960
Complete paper in Geophysics, V. 26, No. 3, pp. 355-358.

L-10 Present and Future Parameters in Acoustic Logging

R. A. BRODING, Century Geophysical Corp.
July 15, 1960

L-11 Giants at Little Valley

Film by Atlas Powder Co.
September 9, 1960

L-12 The Geograph as a New Tool in Seismic Exploration

GEORGE L. LAIRD, Robert H. Ray Co.
October 21, 1960

L-13 Stratigraphic and Structural History of the Canadian Arctic Islands

E. T. TOZER, A.A.P.G. Distinguished Lecturer
November 5, 1960

M.

GEOPHYSICAL SOCIETY OF EDMONTON
Edmonton, Alberta
(Chartered March 20, 1959)

M-1 Some Recent Gravity Surveys—Regional and Local

G. D. GARLAND, University of Alberta
September 22, 1959

M-2 Optical Analog Gravity Computer

R. W. BALTOSSER, Seismograph Service Corp.
October 26, 1959

Abtsract

The SSC Optical Analog Gravity Computer is an instrument which indicates the simulated gravity values of a geologic model. The models are made by sketching to scale sections which represent the earth's densities. When the model is examined in the instrument, the readings simulate gravity values. These simulated gravity values may then be compared to Bouguer gravity values taken from an actual survey.

The geologic sections are prepared in a conventional manner with shading controlling the simulated densities. The models can be easily modified by changing the shading and the resulting gravity values quickly redetermined.

Both two and three-dimensional models may be examined with the choice of several scale ratios.

The theory of the instrument is described and its limitations and possibilities discussed. Examples of gravity profiles from local and typical cross-sections are shown.

M-3 Direct Reading Porosity from Velocity Logs

J. W. FERGUSON, Seismograph Service Corp.
November 18, 1959

M-4 Seismic and Sparker Operation on the MacKenzie River

Film and comments by A. E. PALLISTER, Accurate Exploration Co.
December 15, 1959

M-5 Measurement and Interpretation of Airborne Magnetometer Data

WAYNE HOYLMAN, Geophysical Consultant
January 15, 1960

M-6 Current Projects of the S.E.G.

FRANK SEARCY, First Vice-President of S.E.G.
February 17, 1960

M-7 Key to the Future of Geophysics—Improved Interpretation

T. O. HALL, President of S.E.G.
February 17, 1960
(See No. 9)

M-8 Exploration Coordination, Souris Valley Area—Saskatchewan, Canada

D. H. PARRY, Imperial Oil Ltd.
March 15, 1960

M-9 Collection and Processing of Digitized Acoustic Log Data

J. L. POOLE, Century Geophysical Corp.
April 19, 1960

M-10—Datum Corrections in Glacial Drift

A. R. PATTERSON, Exploration Consultants, Inc.
May 24, 1960

M-11 The Preparation of Seismic Depth Maps in Oil Exploration

A. E. PALLISTER, Accurate Exploration Co.
January 24, 1961

M-12 The Future of Geophysics

J. P. WOODS, President of S.E.G.
February 28, 1961

M-13 The Role of Geophysics in the Geological Survey of Canada

GEORGE D. HOBSON, Geological Survey of Canada
March 28, 1961

M-14 Velocity Determinations from Reflection Data

ARNE JUNGER, Shell Oil Co. of Canada
May 2, 1961

M-15 Gravity and Magnetics for Seismologists

L. L. NETTLETON, Geophysical Associates International
May 18, 1961
(See No. W-2)

N.

GEOPHYSICAL SOCIETY OF HOUSTON
Houston, Texas
(Chartered February 14, 1948)

N-1 Recognition and Use of Cross-Energy on Seismic Records

W. A. SAX, Union Oil Co. of California
October 19, 1959

N-2 How Fast Does a Salt Dome Grow?

PAUL WEAVER, Texas A. and M. College
November 23, 1959

N-3 The Problems in Drilling in the Moho Layer

WILLARD BASCOM, S.E.G. Distinguished Lecturer
January 28, 1960
(See No. G-3)

N-4 Under Water Seismic Profiling with the Sparker and Gas Exploder

CHARLES B. OFFICER, Marine Geophysical Services Corp.
February 15, 1960
(See No. W-9)

N-5 Current S.E.G. Projects and Problems

FRANK SEARCY, First Vice-President of S.E.G.
March 21, 1960

N-6 Key to the Future of Geophysics, Improved Interpretation

T. O. HALL, President of S.E.G.
March 21, 1960
(See No. 9)

N-7 The Atlantic Coastal Plain

GEORGE T. WOOLLARD, University of Wisconsin
April 25, 1960

N-8 A Terrestrial Theory of Ice Ages

WILLIAM L. DONN, A.A.P.G. Distinguished Lecturer
June 10, 1960
(See No. T-15)

N-9 Highlights of the International Union of Geodesy and Geophysics Meeting at Helsinki, Finland

JOHN ADAMS, Western Geophysical Co. of America; SAM T. WORDEN, BURTON LEE, Texaco, Inc.; and L. G. HOWELL, Humble Oil and Refining Co.
September 19, 1960

N-10 Continental Drift

S. K. RUNCORN, Durham College, England
September 21, 1960

N-11 The Broad Earth Science Objectives of Rice University

JOHN ROGERS
October 17, 1960

N-12 The Geophysics Program at Rice University

J. C. DeBREMAECKER, The Rice Institute
October 17, 1960

N-13 Filtering and Correlation of Seismic Data

CARL WISCHMEYER, The Rice Institute
November 21, 1960

O.

GEOPHYSICAL SOCIETY OF OKLAHOMA CITY
Oklahoma City, Oklahoma
(Chartered September 30, 1952)

O-1 Pennsylvanian Stratigraphy of the Anadarko Basin

PAUL L. LYONS, Sinclair Oil and Gas Co.
September 21, 1959

O-2 The Use of Gravity and Magnetics in Solving Geologic Problems

R. A. GEYER, Geophysical Service, Inc.
October 12, 1959
(See No. T-10)

O-3 Drilling to the Mohorovicic Layer

WILLARD BASCOM, S.E.G. Distinguished Lecturer
November 23, 1959
(See No. G-3)

O-4 Well Logging and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.
January 18, 1960
(See No. C-18)

O-5 Elimination of Seismic Ghost Reflections by Means of a Linear Filter

J. P. LINDSEY, Phillips Petroleum Co.
February 8, 1960
(See No. 5)

O-6 A Guide to the Determination of Seismic Reflection Quality and Its Relation to Exploration Costs

C. NEWTON PAGE, Continental Geophysical Co.
March 24, 1960
(See No. 4)

O-7 Key to the Future, Improved Interpretation

T. O. HALL, President of S.E.G.
April 14, 1960
(See No. 9)

O-8 Current and Future Parameters in Geophysics

R. A. BAILE, Empire Geophysical Co.
May 24, 1960
(See No. L-9)

O-9 Comparisons of Weight Drop and Shooting Methods

C. L. KIMBELL, Independent Exploration Co.
September 19, 1960

O-10 Operations Research—A Tool in Oil Exploration

HOWARD COBB, The Atlantic Refining Co.
October 17, 1960
Complete paper in Geophysics, V. 25, No. 5, pp. 1009-1022.

O-11 Some Aspects of Refraction Interpretation

M. E. TROSTLE, Geophysical Service, Inc.
November 21, 1960
(See No. W-1)

O-12 Some Aspects of the Generation of Harmonic Distortion in a Seismic System

W. R. MITCHELL, National Geophysical Co.
January 16, 1961
(See No. T-12)

O-13 The Review of the Use of Magnetic Tape

J. P. WOODS, President of S.E.G.
February 20, 1961

O-14 Gravity and Magnetics for Seismologists

L. L. NETTLETON, A.A.P.G. Distinguished Lecturer
March 7, 1961
(See No. W-2)

O-15 Continental Gravity

PAUL L. LYONS, Sinclair Oil and Gas Co.
May 15, 1961

O-16 Theory versus Practice in Gravity Analysis

BOB SCOTT, Consulting Geophysicist and Geologist
May 25, 1961

P.

GEOPHYSICAL SOCIETY OF SOUTH TEXAS
San Antonio, Texas
(Chartered November 9, 1953)

P-1 A Discussion of Contouring

PORTER MONTGOMERY, South Texas Stratigraphic Service
March 1, 1960

P-2 Back of Beyond

Film by Shell Oil Co.
April 5, 1960

P-3 Seismic Operations in Columbia

W. LEE MOORE, Petty Geophysical Engineering Co.
October 31, 1960

P-4 Operation Abolition

Film on communist riots in San Francisco
December 6, 1960

Q.

JACKSON GEOPHYSICAL SOCIETY
Jackson, Mississippi
(Chartered May 12, 1955)

Q-1 Oil and Gas Industry in Mississippi

JAMES F. BORTHWICK, JR., Mississippi State Oil and Gas Board
September 28, 1959

Q-2 A Progress Report on the Use of Elcord Delay Units

BOB R .MILLER, E. I. DuPont de Nemours Co.
October 26, 1959

Q-3 Well Logging and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.
November 30, 1959
(See No. C-18)

Q-4 Key to the Future—Improved Interpretation

T. O. HALL, President of S.E.G.
January 18, 1960
(See No. 9)

Q-5 Acoustic Logging—A New Technical Parameter

HOWARD ITTEN, Empire Geophysical Co.
January 18, 1960

Q-6 Seismic Data Enhancement

ROBERT J. GRAEBNER, Geophysical Service, Inc.
February 15, 1960
(See No. A-10)

Q-7 An Analog Seismic Correlator

L. C. CUMMINGS, Humble Oil and Refining Co.
March 14, 1960
Complete paper in Geophysics, V. 26, No. 3, pp. 298-308.

Q-8 Seismic Exploration in Mississippi

C. W. NICHOLLS, Western Geophysical Co. of America
May 9, 1960

Q-9 Underground Nuclear Explosions in South Mississippi

ANDREW J. SUTTLE, JR., Mississippi Industrial and Technological Commission
November 28, 1960

Q-10 A Method for Obtaining Seismic Velocity Data Using Well Logs and Seismograms

STUART C. MUT, The Atlantic Refining Co.
January 23, 1961

Q-11 Operation and Use of the Del-tex Impulse Blaster

EWIN GABY, JR., Delta Exploration Co., Inc.
February 20, 1961

Q-12 The Future of Geophysics

J. P. WOODS, President of S.E.G.
March 13, 1961

Q-13 Horizontal Data Stacking

W. HARRY MAYNE, Petty Geophysical Engineering Co.
April 17, 1961

R.

MONTANA GEOPHYSICAL SOCIETY
Billings, Montana
(Chartered April 12, 1954)

R-1 Continuous Velocity Logs

H. W. HARDY, Humble Oil and Refining Co.
September 21, 1959
(See No. D-1)

R-2 The Dependence of Seismic Pulse Form and Frequency Content on Shot Variables

V. R. JOHNSON, Jersey Production Research Co.
November 5, 1959

Detailed field experiments were performed to determine how charge size, depth, and length affect seismic pulse form and frequency content. Downward and upward traveling pulses were observed at distances ranging up to 400 feet from the shot, and reflection records were recorded simultaneously. A cemented vertical array of geophones was used to provide undistorted recording of subsurface waveforms.

Downward-traveling pulse form proved to be sensitive to all three variables. Increased charge size and length usually resulted in pulse broadening. Major changes in pulse structure, however, are related to shot depth. These changes are apparently caused not so much by variations in the medium surrounding the shot as by layer geometry which affects the phase relationships of pulses reflected downward from layers above the shot. In contrast to downward-traveling pulses, uphole waveforms were found to broaden greatly with increasing charge size. Fourier analysis of all down-traveling pulses were made to permit direct examination of that part of the spectrum lying in the reflection band of frequencies. These analyses show relatively minor changes in shape of the spectral curves in this region as charge size and length were varied. Charge depth variations, on the other hand, cause spectral nulls or

inflections which can be correlated with character changes on reflection records. Other supplemental topics, such as ultrashallow reflection recording on the array of subsurface cemented geophones, are discussed briefly.

R-3 Efficiency of Seismic Operations

A panel discussion by D. W. CAREY, W. H. DAWSON, S. D. BRASEL and R. E. WHITMORE

December 7, 1959

R-4 Mistakes in Geophysical Prospecting

H. M. THRALLS, Geo Prospectors, Inc.

January 11, 1960

(See No. D-5)

R-5 Blasting—Cause and Effect and Free Nuclear Precession Magnetometer

Films by Hercules Powder Co. and Varian Associates

February 15, 1960

R-6 It Never Rains Oil

Film shown by Jack Bailey, Gulf Oil and Refining Co.

March 9, 1960

R-7 Conquering Ripple Rock

Film by E. I. DuPont de Nemours Co.

September 26, 1960

R-8 Production and Processing of Digitized Well Log Data

R. A. BRODING, Century Geophysical Corp.

January 9, 1961

(See No. C-6)

S.

NEW MEXICO GEOPHYSICAL SOCIETY

Roswell, New Mexico

(Chartered September 18, 1957)

S-1 Evaluation, Handling and Storage of Magnetic Tapes

ROBERT B. FISHER, Davis Equipment Co.

July 20, 1959

(See No. K-2)

S-2 A Review of Dip Meter Well Logging and the Determination of Dip with an Electronic Dip Log Correlator

J. H. SASSEEN, Humble Oil and Refining Co.

August 17, 1959

S-3 Geologic and Scenic Highlights of Our 49th State

BRUNO HANSON, Humble Oil and Refining Co.
September 21, 1959

S-4 Principles of Petroleum Occurrence and Pertinent Remarks on Present Operation of A.A.P.G.

L. G. WEEKS, President of A.A.P.G.
October 21, 1959

S-5 The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer
November 17, 1959
(See No. G-3)

S-6 Use of the CVL in the Petroleum Industry

H. W. HARDY, Humble Oil and Refining Co.
January 19, 1960
(See No. D-1)

S-7 Present and Future Parameters in Geophysics

DICK BAILE, Empire Geophysical Co.
February 11, 1960
(See No. L-9)

S-8 Seismic Exploration of the Val Verde Basin

LORENZ SHOCK, Midland Geophysical Co.
March 10, 1960

S-9 What is a Professional Man?

J. CALDWALD WILSON, President of New Mexico Society of Engineers and
TOM MANN, New Mexico Society of Professional Engineers
April 14, 1960

S-10 Case History of North Bronte—Rawlings Field, Coke County, Texas

ROLLIN E. PHIPPS, Lion Oil Co.
May 17, 1960
Complete paper in Geophysics, V. 25, No. 6, pp. 1167-1183.

S-11 Comparisons of Weight Drop and Shooting Methods

CHARLES L. KIMBELL, Independent Exploration Co.
June 7, 1960

S-12 Guided Missiles

MAJ. ROBERT G. BECKNELL, United States Army
July 5, 1960

S-13 Is the Capitan Formation of Reef Origin?

H. S. CAVE, Consulting Geologist
August 2, 1960

S-14 Ground Water in New Mexico and Its Relationship to Seismic Prospecting

JAMES W. HOOD, United States Geological Survey
September 6, 1960

S-15 Guide to the Determination of Seismic Reflection Quality and Its Relationship to Exploration Cost

C. NEWTON PAGE, Continental Geophysical Co.
November 1, 1960
(See No. 4)

S-16 Exploration Techniques in Mining on the Surface, Underground and in Drill Holes

A. A. BRANT, S.E.G. Distinguished Lecturer
December 7, 1960

S-17 A Trip to Europe and North Africa

Film and slides by R. L. TUCKER, Sinclair Oil and Gas Co. and
KENNETH WEBB, Seismic Exploration, Inc.
January 10, 1961

S-18 Communism on the Map

ROYCE E. LAWSON, Humble Oil and Refining Co.
February 7, 1961

S-19 Brief Case for Business

DICK HOLT, Humble Oil and Refining Co.
March 7, 1961

S-20 Highways and Gasoline Tax

L. H. VAN DYKE, Shell Oil Co.
March 7, 1961

S-21 Least Squares Approach to the Residual Analysis of Gravity Data

THOMAS J. BEVAN
May 9, 1961

T.

PACIFIC COAST SECTION S.E.G.
Los Angeles, California
(Chartered April 12, 1958)

T-1 Underwater Motion Picture Cameras and Closed Circuit Television as Used in Submarine Research by the U. S. Navy, Scripps Institute and Other Organizations

JON HALL, Sampson-Hall Co.

September 10, 1959

T-2 A Place for Research in Geophysical Prospecting

C. HEWITT DIX, California Institute of Technology

October 8, 1959

T-3 Blasting Vibrations—Cause and Effect

C. A. DESMOND, Hercules Powder Co.

December 10, 1959

T-4 Tour of Techno Instrument Company Plant

J. M. CUNNINGHAM, Techno Instrument Co.

January 14, 1960

T-5 The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer

January 29, 1960

(See No. G-3)

T-6 Geomagnetic Measurements from the Space Probes

C. P. SONETT, Space Technology Laboratories

March 10, 1960

Annual Spring Meeting

April 8, 1960

T-7 Seismic Operations in the Jungles of Peru

NEAL L. HURLEY, Richfield Oil Corp.

A reconnaissance seismic program was conducted in 1958 by G.S.I. in the Maranon Basin of Peru for Peruvian Pacific Petroleum Company, a subsidiary of Richfield and Cities Service. Field operations were conducted chiefly along river courses which provide access routes across the heavily overgrown jungle. Fortunately, good reflecting horizons occur at the top of the Mesozoic and at the top of the Paleozoic sections.

T-8 The Interpretation of Geology from the Derivatives of Aeromagnetic Data

H. WAYNE HOYLMAN, Consultant

This paper illustrates the use of derivatives to help distinguish between anomalies that reflect relief on the basement complex as against those that reflect merely small changes in the chemical composition of the rocks. The theoretical distinction between such geological conditions is relatively simple

and straightforward. However, under actual field conditions resulting from the heterogeneity of the basement complex, the interpretation of these two types of geological conditions are somewhat more difficult. Correlations between derivative anomalies and oil fields are discussed.

T-9 Reconnaissance Geology of Western Libya

STEWART CHUBER, Mobil Oil Co.

A fairly complete section of Paleozoic, Mesozoic and Tertiary rocks, totaling over 10,000 feet in composite thickness, crop out in Libya. In general, the sediments are mature types, clean sandstones, with shale and a high proportion of limestone and marl. Tertiary strata crop out extensively in central and eastern Libya (in part called the Sirte basin) where concentrated efforts by the oil companies have recently paid off with a number of oil discoveries.

T-10 Gravity and Magnetics in an Exploration Program

RICHARD A. GEYER, Geophysical Services, Inc.

Information about geologic structure can be deduced from the observed gravitational field by means of examples. Faults, long anticlines, domes and basement features cause gravity anomalies of different types. These types respond to variations in magnitude, depth, spacing, and density change in different ways. Attention is also given to the type of information to be derived from magnetics in an exploration program.

T-11 Corrections of Seismic Interpretations in Glaciated Areas by the Use of Gravity Data

B. F. GROSSLING, California Research Corp.

Gravity was used in Chile to demonstrate that some of the positive structures indicated by seismic work were in reality only the effect of irregularities in the glacial mantle.

T-12 An Evaluation of Seismic System Distortion

W. R. MITCHELL, National Geophysical Co.

The complete seismic system as considered by the author embraces the entire seismic path from the shot point to the final seismogram. Distortion may and, in fact, does occur in any portion of this system. The effect on the seismogram, however, will depend on the magnitude of the various distortion factors and their location with respect to the other distortion producing elements.

In the opinion of the author, the effect of the various distortion factors is of particular interest to the seismologist and seismic interpreter. Therefore, the author has endeavored to present this information in a form that can be readily understood by those without specific training in the field of electronics.

T-13 Stratigraphy versus Noise

CARL H. SAVIT, Western Geophysical Co. of America
(See No. D-9)

T-14 Underwater Seismic Profiling with the Sparker and Gas Exploder

CHARLES B. OFFICER, Marine Geophysical Services Corp.

May 12, 1960

(See No. W-9)

T-15 A Terrestial Theory of the Ice Ages

WILLIAM L. DONN, A.A.P.G. Distinguished Lecturer

May 27, 1960

Joint meeting with Pacific Section A.A.P.G.

"The direct cause of Pleistocene glaciation of the Northern Hemisphere is explained on the basis of an ice-free Arctic Ocean. This would provide the initial precipitation and would effect changes in atmospheric and oceanic circulation that would further enhance glacial growth. The lowering of sea level associated with glacial growth would finally cause the Arctic to freeze over, terminating glacial conditions. Glacial-interglacial oscillations are thus dependent on the state of the Arctic Ocean which is in turn regulated by sea level position. The initiation of the glacial epoch is explained by the displacement of the geographic poles from an open ocean environment to their present thermally isolated locations in the Arctic Ocean and Antarctica, respectively."

T-16 Results of a Refraction Survey in the Heletz-Negba Area, Israel

M. L. BEHR, California Institute of Technology

June 9, 1960

T-17 Tour of California Research Corporation Facilities

N. A. RILEY, California Research Corporation

September 8, 1960

T-18 A Report on Airborne AFMAG

W. C. KELLOGG, Fairchild Aerial Surveys, Inc.

October 13, 1960

Annual Joint Meeting of Pacific Sections of S.E.G., A.A.P.G. and S.E.P.M.

November 3-4, 1960

T-19 Preliminary Gravity Results in the Imperial Valley

R. L. KOVACH, California Institute of Technology

T-20 Bouguer Gravity Map of Alaska

L. F. IVANHOE, Consultant

T-21 The Line Source Problem for a Solid-Solid Interface

S. J. LASTER and FREEMAN GILBERT, Geophysical Service, Inc.

T-22 Gravity Prospecting for Reefs; Effect of Sedimentation and Differential Compaction

SULHI YUNGUL, California Research Corp.

Complete paper in Geophysics, V. 26, No. 1, pp. 45-56.

T-23 Petroleum Exploration with the Gas Exploder and Sparker—Offshore California

CHARLES B. OFFICER, Marine Geophysical Services Corp.

T-24 Solving the Singing Record

CARL H. SAVIT, Western Geophysical Co. of America

T-25 Metal Mining and Exploration

A. A. BRANT, S.E.G. Distinguished Lecturer
December 12, 1960

T-26 Techniques of Aeromagnetic Surveying and Map Compilation

WILLIAM C. KELLOGG, Fairchild Aerial Surveys, Inc.
January 12, 1961

U.

PERMIAN BASIN GEOPHYSICAL SOCIETY
Midland, Texas
(Chartered January 30, 1950)

U-1 Paleozoic Geology of the Delaware and Val Verde Basins

CHARLES D. VERTREES, Consulting Geologist
September 8, 1959

U-2 Oil Exploration from the Research Viewpoint

JAMES F. JOHNSON, Sinclair Research Laboratory
October 13, 1959

U-3 Problems in Drilling to the Mohorovicic Layer

WILLARD BASCOM, S.E.G. Distinguished Lecturer
November 18, 1959
(See No. G-3)

U-4 Free Fall from High Altitude

CAPT. JOSEPH W. KITTINGER
January 12, 1960

U-5 Marine Seep Detection—A New Reconnaissance Tool

JOHN S. BRADLEY, The Atlantic Refining Co.
February 9, 1960
(See No. G-1)

U-6 Past and Future of the Permian Basin

TED JONES
March 8, 1960

U-7 Case History—North Bronte-Rawlings Field, Coke County, Texas

ROLLIN E. PHIPPS, Lion Oil Co.
April 12, 1960
(See No. S-10)

U-8 A Theory of the Ice Ages

WILLIAM L. DONN, A.A.P.G. Distinguished Lecturer
May 24, 1960
Joint meeting with West Texas Geological Society
(See No. T-15)

U-9 Application of Refraction—Delaware Basin

M. E. TROSTLE, Geophysical Service, Inc.
September 13, 1960
(See No. G-10)

U-10 Photo Travelog of the Interior of Alaska

JOHN BROCK, The Superior Oil Co.
October 11, 1960

U-11 Oil Accumulation Along Abo Reefing in Southeastern New Mexico

WILLIAM J. LeMAY, Hondo Oil and Gas Co.
November 16, 1960

U-12 Mistakes in Geophysical Prospecting

H. M. THRALLS, Geo Prospectors, Inc.
January 10, 1961
(See No. D-5)

U-13 Structure of the Continental Margin of Northeastern North America

CHARLES L. DRAKE, Lamont Geological Observatory
January 19, 1961
Joint meeting with West Texas Geological Society

V.

REGINA GEOPHYSICAL SOCIETY
Regina, Saskatchewan
(Chartered March 20, 1959)

V-1 Effects of Changing Stratum Thicknesses on Reflection Seismograms

RAYMOND A. PETERSON, United Geophysical Co.
October 26, 1959

V-2 Various Aspects of Velocity, or Acoustic, Logging

R. A. BRODING, Century Geophysical Corporation and
J. W. FERGUSON, Seismograph Service Corp.
November 20, 1959

V-3 Key to the Future of Geophysics—Improved Interpretation

T. O. HALL, President of S.E.G.
February 16, 1960
(See No. 9)

V-4 The Affairs of the Society of Exploration Geophysicists

FRANK SEARCY, First Vice-President of S.E.G.
February 16, 1960

V-5 Exploratory Coordination—Souris Valley Area, Saskatchewan

D. H. PARRY, Imperial Oil Ltd.
March 29, 1960
(See No. C-12)

V-6 The Application of Geophysical Methods to Ground Water Exploration in Saskatchewan

D. H. HALL, University of Saskatchewan
April 26, 1960

V-7 An Account of an Aerial Reconnaissance Trip to the Arctic Islands

D. C. SKEELS, Imperial Oil Ltd.
June 7, 1960

V-8 The Engineering Profession Act, 1961

TOM TAMAKI, Department of Mineral Resources
November 22, 1960

V-9 Highlights of the S.E.G. Convention

A. C. ARMSTRONG, British American Oil Co.
November 22, 1960

V-10 A Field Demonstration of Hunting's Seismic Refraction Time Counter

D. L. SURJIK, California Standard Co.
November 22, 1960

V-11 Metal Mining and Exploration

A. A. BRANT, S.E.G. Distinguished Lecturer

November 30, 1960

W.

SOUTHEASTERN GEOPHYSICAL SOCIETY

New Orleans, Louisiana

(Chartered April 1, 1954)

W-1 Some Aspects of Refraction Interpretation

M. E. TROSTLE, Geophysical Service, Inc.

September 21, 1959

A field program of maximum effect in solution of the geologic problem of the prospect can be designed prior to the refraction work through study of existing geological and geophysical information. Some of the factors which must be considered in this study and in the interpretation of the refraction time anomalies include the possibility of multiple refractions, the possibility of composite events, the geometry of the spread in relation to the anomaly and the placement of the depth points.

Visual aids, such as corrected wiggle trace or variable density sections are an aid in identifying diffraction and secondary events.

The location of the depth points where subsurface is complex and the analysis of diffraction from a fault presents a problem that can often be solved by graphical methods.

W-2 Gravity and Magnetics for Seismologists

L. L. NETTLETON, Geophysical Associates International

October 19, 1959

Approximately 80 to 90 percent of current total geophysical expenditure is for reflection seismograph exploration. For this reason, the term "geophysicist," to a large extent, has come to mean seismologist, and any geophysical operation is likely to be called "shooting." This situation has lead to a lack of appreciation by many "geophysicists" of the place of other methods, principally gravity and magnetics, in the over-all exploration program. The paper will review the basic principles of these "potential theory" methods and their usefulness and will illustrate their application in both reconnaissance and detailed, quantitative exploration.

W-3 Studies of Faults, Interference and Noise Patterns

LORENZ SHOCK, Midland Geophysical Co.

November 16, 1959

Through use of a multidrum magnetic playback unit and a programmed delay data processing system recordings can be combined to simulate various seismic interpretative problems. Results are presented showing the effects of

various types of faults; interference patterns from synclines, etc.; and controlled amounts of random and systematic "noise" on a good seismic recording.

W-4 On Seismic Noise

M. R. MacPHAIL, Humble Oil and Refining Co.

December 21, 1959

Seismic noise, as defined for this discussion, denotes the incoherent part of a seismogram, that is, the part that persistently fails to "carry" across a spread of conventional length. In areas regarded as seismically difficult, the coherence, or more precisely the correlation coefficient between pairs of traces, generally appeared to decrease monotonically to zero with increasing separation between pickups, the rate of decrease varying from area to area. In areas where reflections were fairly evident the coherence leveled off at a certain positive value determined by the strength of the reflections.

The seismic noise from quite a large number of localities studied appeared to be random resulting from the superposition of many events. Randomness in arrival times could result from either a random distribution of sources in the earth, or variation in seismic velocity from point to point, or both. Noise is seismic energy scattered by many small, randomly distributed inhomogenities. Calculations based on this premise lead to a coherence–distance relation that is qualitatively similar to those observed. By means of the coherence-distance relation for a particular area, it is possible to specify a pickup pattern that will effectively increase the ratio of coherent to incoherent energy. Examples will be given and discussion invited.

W-5 The Mohole Project

WILLARD BASCOM, S.E.G. Distinguished Lecturer

January 27, 1960

(See No. G-3)

W-6 Velocity Logging—A New Family

HOWARD ITTEN, Empire Geophysical Co.

February 15, 1960

W-7 Synthetic Records

K. S. TOWNSEND, Seismograph Service Corp.

February 15, 1960

W-8 Nature and Growth of Southern Louisiana Salt Domes and Its Effect on Petroleum Accumulation

GORDON ATWATER, Geological Consultant

March 21, 1960

Complete paper in Bull. A.A.P.G., V. 43, No. 11, pp. 2592-2622.

W-9 Underwater Seismic Profiling with the Sparker and Gas Exploder

CHARLES B. OFFICER, Marine Geophysical Services, Inc.

April 18, 1960

The Continuous Seismic Profiler (Sparker) was developed at the Woods Hole Oceanographic Institution. It maps in a continuous manner strata beneath the water bottom down to depths on the average of 600-800 ft. The method of operation is similar to that of a conventional echo sounder; the results are presented in the form of a geologic cross section. The structual configuration at these depths is shown in detail. A number of surveys have been made with the Sparker for petroleum exploration and marine engineering purposes; the results of some of these surveys will be shown.

The Continuous Seismic Profiler (Gas Exploder) was developed recently by the Lamont Geological Observatory. Its operation is similar to that of the Sparker with a change in the seismic source. The Gas Exploder obtains results down to depths of a few thousand feet. Records from Gas Exploder surveys will also be shown.

W-10 Well Logging and Magnetic Tape

J. P. WOODS, The Atlantic Refining Co.
May 16, 1960
(See No. C-18)

W-11 The Future of Oil Exploration

J. P. WOODS, President of S.E.G.
November 21, 1960

W-12 Seismic Exploration in Mississippi

CHARLES P. BRAGG, Union Producing Co. and
CHARLES W. NICHOLLS, Western Geophysical Co. of America
December 19, 1960

W-13 Geology and Geophysics in Russia

NEAL J. SMITH, Chevron Oil Co.
January 16, 1961

X.

SOUTHWEST LOUISIANA GEOPHYSICAL SOCIETY
Lafayette, Louisiana
(Chartered January 4, 1956)

X-1 Some Aspects of Refraction Interpretation

M. E. TROSTLE, Geophysical Service, Inc.
September 22, 1959
(See No. W-1)

X-2 Case History of Washington Field, St. Landry Parish, Louisiana

NEAL CLAYTON, Sohio Petroleum Co.
October 20, 1959

X-3 Gulf Coast Faulting and Low Relief Structures

NED PRATT and JOE GRAGNON, Petty Geophysical Engineering Co.
November 16, 1959

X-4 S.E.G. Affairs

FRANK SEARCY, First Vice-President of S.E.G.
January 19, 1960

X-5 Key to the Future of Geophysics—Improved Interpretation

T. O. HALL, President of S.E.G.
January 19, 1960
(See No. 9)

X-6 Twelve Ways to Find a Stratigraphic Trap

ROGER MATSON, A.A.P.G. Distinguished Lecturer
January 19, 1960

X-7 Recognition and Use of Cross Energy on Seismic Records

WILLIAM A. SAX, Union Oil Co. of California
February 16, 1960

X-8 Operation Mohole

WILLIAM B. HEROY, Geotechnical Corp.
March 24, 1960

X-9 Stratigraphy versus Noise

CARL H. SAVIT, Western Geophysical Co. of America
April 5, 1960
(See No. D-9)

X-10 Some South Louisiana Faults

J. T. MURPHY, The Atlantic Refining Co.
September 16, 1960

X-11 The Future of Exploration

J. P. WOODS, President of S.E.G.
October 11, 1960

X-12 Seismic Decoupling for Explosions in Spherical Cavities

W. M. ADAMS, University of California
November 3, 1960

X-13 The Continuous Seismic Profiler (Gas Exploder)

CHARLES B. OFFICER, Marine Geophysical Services Corp.
December 13, 1960
(See No. W-9)

Y.

UTAH GEOPHYSICAL SOCIETY
Salt Lake City, Utah
(Chartered October 29, 1956)

Y-1 Crustal Studies of the Eastern Portion of the Basin and Range Province

J. BERG, University of Utah
Complete paper in Bull. Seis. Soc. Amer., V. 50, No. 4, pp. 511-536.

Y-2 The Investigation of P-S Exchange Waves Resulting from Large Explosions

J. J. SCHWIND, University of Utah
October 30, 1959
Complete paper in Jour. Geoph. Res., V. 65, No. 11, pp. 3817-3824.

Y-3 Geophysical Parameters

E. V. McCOLLUM, E. V. McCollum and Co.
November 24, 1959

Y-4 Trap Barriers—Hydrodynamic, Stratigraphic and Wettability

GILLMAN A. HILL, A.A.P.G. Distinguished Lecturer
December 11, 1959

Y-5 Hydrodynamic Control of Gas and Oil Accumulation

F. BERRY
December 17, 1959

Y-6 Creativity versus Exploration Problems

JOHN M. CRAWFORD, Continental Oil Co.
January 14, 1960
(See No. H-5)

Y-7 Drilling to the Moho

WILLARD BASCOM, S.E.G. Distinguished Lecturer
February 3, 1960
(See No. G-3)

Y-8 Understanding Oil Problems

JOHN KLAS, Utah Petroleum Council
March 18, 1960

Y-9 Progress in Distributed Charge Shooting Techniques

B. MILLER, Seis-Tech Exploration Co.
April 26, 1960

Y-10 Conquering Ripple Rock

Film by E. I. duPont de Nemours and Co.
May 20, 1960

Y-11 Gravity—Magnetics Seminar

Conducted by R. A. GEYER, Geophysical Service, Inc.
December 2, 1960

Y-12 Exploration Methods and Procedures the Student Will Encounter in Industry

L. D. OSTER, JOHN ERWIN and JIM LaFEVERS
January 12, 1961

CONSTITUTION AND BY-LAWS

(*As amended to Feb.* 9, 1961)

ARTICLE I

The name of this Society is the *Geophysical Society of Tulsa*. It shall be the Tulsa Section of the Society of Exploration Geophysicists.

ARTICLE II

OBJECT

The object of this Society is to promote the science of geophysics especially as it applies to exploration, and to promote fellowship and cooperation among those persons interested in geophysical problems.

ARTICLE III

MEMBERSHIP

1. Any person interested in the geophysical profession shall be eligible for membership.
2. Applications for membership shall be submitted in writing, and shall be signed by three sponsors who are members of the Society.
3. Application shall be approved for membership by the Executive Committee.
4. The annual dues of members of the Society shall be three dollars ($3.00) payable in advance on the first day of each calendar year.
5. Members whose applications are approved after July 1 shall be required to pay only one-half of the regular annual dues for the remainder of the first year of membership.
6. Charter Members of this Society will be those who attended the first organizational meeting of the Society on February 4, 1947, or who attended the second meeting on March 13, 1947, and signed the respective roll as charter members, and who have paid dues for the year 1947.
7. Honorary Members of this Society shall be elected by unanimous vote of the Executive Committee. To be eligible for Honorary Membership, a person must have attained the age of sixty and must have made outstanding contribution or contributions to the geophysical profession in general or to this Society in particular. Honorary Members shall receive all publications and meeting announcements of the Society but shall not be required to pay dues or any special assessments.

ARTICLE IV

RESIGNATION AND SUSPENSION

1. Any member may resign from the Society at any time. Such resignation shall be in writing and shall be accepted by the Executive Committee, subject to the payment of all outstanding dues and obligations of the resigning member.

2. Any member who is more than one year in arrears in payment of dues shall be dropped from the Society. Any member, at his own option, may request in writing that he be dropped from the Society and such request shall be granted by the Executive Committee after due notification.

3. Any person who has ceased to be a member under Section 1 or Section 2 of the Article may be reinstated by unanimous vote of the Executive Committee subject to the payment of any outstanding dues and obligations which were incurred prior to the date when he ceased to be a member of the Society.

ARTICLE V

OFFICERS AND THEIR DUTIES

1. The officers of the Society shall be: President, First Vice-President, Second Vice-President, Secretary, Treasurer, and Editor.

2. There shall be district representatives to the Society of Exploration Geophysicists, as provided in the constitution of that society.

3. The Executive Committee shall consist of the Officers, the two most recent available Past Presidents, and the District Representative, or representatives, to the Society of Exploration Geophysicists.

4. The Officers shall be elected by a ballot as hereinafter provided at the Annual Meetings. The President, First Vice-President, Second Vice-President, Secretary, and Treasurer shall serve for one year. The Editor-elect shall serve for two years, the first year as Assistant Editor, the second year as Editor.

5. The President shall preside at the meetings of the Society and of the Executive Committee. He shall call special meetings when deemed advisable; shall appoint all committees except as otherwise herein provided; and jointly with the Secretary-Treasurer, shall sign all written contracts and other obligations of the Society. In the temporary absence of other officers, he shall assume their duties or delegate them.

6. The First Vice-President shall be responsible for arranging the technical program of the Society, and shall have authority to appoint such assistants as he may require. He shall perform the duties of President

in the absence or disability of that Officer, and in case of the President's resignation shall become President for the remainder of the term.

7. The Second Vice-President shall be responsible for arranging entertainment, and shall have power to appoint members to assist him.

8. The Secretary shall maintain a complete list of the membership of the Society and of its Executive Committee, shall mail advance notice of meetings to all members, shall keep minutes of meetings of the Society, and of its Executive Committee, shall notify the members by mail of proposed amendments to the Constitution, and shall mail and receive ballots.

   The Secretary shall submit to the Secretary-Treasurer of the Society of Exploration Geophysicists a report of each meeting of this Society and of its Executive Committee within two weeks following each such meeting. He shall also submit to the Secretary-Treasurer of the Society of Exploration Geophysicists the names of all Officers and Committee members within two weeks after their election or appointment.

9. The Treasurer shall collect all dues and other obligations to the Society, shall make disbursements authorized by the Executive Committee and shall transact such other business as may be authorized by the Executive Committee. He shall maintain a chronological record of all receipts and expenditures as well as a system of records explaining each expenditure, including evidence of authority to expend funds and evidence of payment. He shall report the condition of the Treasury at each Annual Meeting and at other times upon request of the Executive Committee.

   When so instructed by the Executive Committee, he shall make application to the Secretary-Treasurer of the Society of Exploration Geopsysicists for such portion of the expenses to be borne by that Society, as may be needed, and shall submit to the Secretary-Treasurer of the Society of Exploration Geophysicists, prior to the annual meeting of that Society, an itemized account of the expenditure of such funds as may have been received from the Society of Exploration Geophysicists during the preceding calendar year.

   A quorum of the Executive Committee shall consist of at least four members and approval by at least four members will be necessary to conduct all business of the Society.

10. The Editor shall be in charge of the editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the regular society publication and for special publications, and may accept or reject material offered for publication. He may appoint editorial assistants.

11. The Executive Committee shall transact all business of the Society not otherwise herein specifically provided for. It shall elect all members to the Society, shall authorize all expenditures, shall direct investments of Society funds, shall establish and supervise publications; shall approve and recommend all proposals for special assessments; shall fill vacancies occurring in any office except in the office of President, to which the First Vice-President automatically succeeds, and shall have the power to review all actions and appointments by the Officers.

12. The District Representatives of the Society of Exploration Geophysicists shall represent the Society and its members at meetings of the Council of the Society of Exploration Geophysicists.

ARTICLE VI

ELECTION OF OFFICERS

1. A slate of nominations for officers shall be prepared by a Committee of Nominations consisting of the President and the two most recent available Past Presidents. They must secure the consent of all candidates nominated. This slate, of two or more candidates for each office, shall be prepared and announced to the Society at its regular meeting in March of each year.

   Additional nominations for each office may be made by written petition of ten or more members in good standing. Such nominations must be submitted to the President not later than the close of the regular meeting in April.

   The election of officers shall be by secret mail ballot. The Secretary shall mail to all members, not later than three weeks preceding the Annual Meeting, a ballot listing all candidates properly nominated for each office. Each member voting shall cast one vote for each officer and shall return his ballot to the Secretary in a sealed envelope carrying on the outside his written signature. Only ballots so prepared by members in good standing and received by the secretary by 4 P.M. on the Monday immediately preceding the Annual Meeting shall be valid.

   The Secretary shall indicate which ballots are valid and shall deliver them unopened to the Committee on Nominations. The Committee on Nominations shall supervise the counting of ballots prior to the Annual Meeting. The candidates receiving the greatest number of votes cast for an office shall be declared elected to that office. In case of a tie, the Executive Committee shall decide which of the tied candidates shall be elected.

2. The Committee on Nominations shall prepare a slate of nominations for any posts of district representatives to the Society of Exploration

Geophysicists, which may need to be filled. Additional nominations may be made in manner set forth in Section 1. The election shall be by secret ballot at least three weeks prior to the annual meeting of the Society of Exploration Geophysicists.

ARTICLE VII

MEETING

1. The Annual Meeting shall be held in May of each year, and shall be held on the second Thursday of May, unless otherwise specified by the Executive Committee and due notice given to the membership.
2. The Regular meetings of the Society shall be held on the second Thursday of each month except during the months of June, July, and August, unless otherwise provided by the Executive Committee.
3. Special meetings may be called at any time by the President of the Society.
4. The time and place of regular meetings, the nature of the technical program and the entertainment, shall be determined by the Executive Committee.

ARTICLE VIII

AMENDMENTS

1. The constitution may be amended by a three-fourths vote of the members present at any regular meeting, provided that the proposed amendment has been approved for submittal by the Executive Committee and has been moved at a regular meeting previous to the meeting at which the ballot shall be taken.
2. By-laws may be changed by a majority vote of members present at any regular monthly meeting.
3. Nothing in this Constitution or By-laws shall be inconsistent with the Constitution and By-laws of the Society of Exploration of Geophysicists.

BY-LAWS

I. The Officers and the Executive Committee may arrange for the affiliation with other duly organized groups or societies which by object, aims, constitution or practice are aiding, assisting, or developing the profession of geophysics or allied technology.

II. Until such time as a sufficient number of qualified Past Presidents has been created, so as to provide those members necessary to serve on the Executive Committee as provided in the constitution, these Execu-

tive Committee members shall be chosen by the Society by a majority vote from open nominations at the Annual Meeting.

III. Prior to the Annual Meeting the Treasurer shall close his accounts and submit them to a committee of three members of the Executive Committee designated by the President. These members shall audit the cash book.

The new Treasurer shall accept the Society funds by giving an entry to that effect in the cash book.

IV. The Society shall publish a journal. The journal shall be published at intervals designated by the Executive Committee. All reports to the Society by its officers and committees may be published in the journal. Each issue shall contain a membership list. Each issue shall list all committees. Original papers, reviews, abstracts, notes of information deemed by the Editor to be of interest to the members of the Society shall be published in the journal. *"The editor shall submit at an early date, for the approval by the Executive Committee, a general outline of the proposed contents of the Proceedings."** The Executive Committee may authorize the printing of the journal and may authorize financing and distribution of the journal.

V. The first editor may be elected at a regular session of the Society following passage of this by-law at a regular meeting.

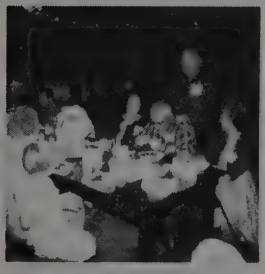
VI. In order to effect the transition from a one-year tenure to a two-year tenure, the incumbent Editor shall serve an additional year as Editor.

RULES FOR THE ADMITTANCE OF NEW MEMBERS

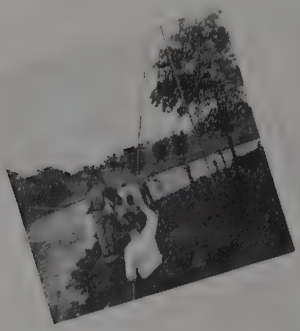
1. Any person interested in the geophysical profession shall be eligible for membership in the Geophysical Society of Tulsa.
2. Applications for membership shall be submitted in writing, and shall be signed by three sponsors who are members of the Society.
3. Applications shall be approved for membership by the Executive Committee.

Note: The Constitution was originally adopted March 13, 1947. It was amended January 8, 1948, November 11, 1958, February 9, 1950, November 13, 1952, and April 10, 1958. The By-Laws were amended February 9, 1950, November 13, 1952, and February 9, 1961.*

1961



picnic



1961

picnic

MEMORIAL

MAURICE HUDIBURG WALLACE

Maurice Hudiburg Wallace, former Standard Oil Co. (N. J.) geologist, died of a heart attack in Muskogee, Oklahoma, on Sunday, July 9, 1961. Surviving are his mother, Mrs. Lorraine Wallace of Muskogee; two brothers and two sisters. Burial was in Ozan, Arkansas. A "Maurice Wallace Memorial Fund" has been set up at the University of Tulsa to provide geological literature for the library.

Since working with Standard Oil Co. (N. J.) Wallace was an instructor in geology for a while at the University of Tulsa and more recently a geological consultant in Muskogee. He was a member of the G. S. T. since December 12, 1957.

Maurice Wallace was born August 22, 1917, in Fairbury, Nebraska. He grew up in Oklahoma, received his BS in geology from Iowa State in 1940 and his MA from the University of Kansas in 1942. He went to work for the Standard Oil Co. (N. J.) in 1942 and resigned in 1954. He crowded an amazingly varied, fruitful and adventuresome career into these twelve brief years, conducting field geology studies in Costa Rica, Ecuador, Dominican Republic, Cuba, Panama, Morocco, Algeria, Angola, Kenya, Madagascar, Turkey, and Libya.

The name, Maurice, gave way to 'Li'l Abner' soon after starting work. After all, he was six feet five and big all over. Li'l Abner's wonderful sense of humor was one of his most attractive qualities. He was always cheerful and never failed to find something to laugh about, even under the most trying circumstances. Certainly he would not approve a serious or platitudinous memorial.

His anecdotes are legion. His reason for joining the G. S. T. supposedly was "to keep those doodle-buggers honest." The SONJ files are replete with his humor. Typical are the following excerpts from his reports.

"Even though we were driving through the vast expanses of the Sahara Desert we had ever present reminders of the benefits of western civilization —both sides of the road were lined with barbed wire entanglements and mine fields. These are quite beneficial as they discourage our competitors from exploring these areas. We have discovered that the best prophylatic against mine fields is the same as that used against rattlesnakes.

"At the Serdeles Police Post we stopped and bought a bunch of bones and feathers which the owner claimed was a chicken. We continued south about 45 kilometers and reached another Quonset Hut at a place called Mourizide. This is supposed to be about the Tropic of Cancer and the area from here to the south is in dispute. (France claims it belongs to Libya and Libya claims it belongs to France.)

"We reached the refuge at the Maret water hole and all took a bath. From here on it is all downhill. Near Gatrun we found an abandoned truck with a load of Italian grenades. I thought about sending a few back to the New York staff for use as paperweights. They say there is always room at the top, but I want to be sure."

W. E. Wallis
(SONJ Exploration Newsletter)
Paul M. Tucker

JAMES LOUIS CATT

Born Oct. 15, 1914

Died April 17, 1960

(Memorial appeared in the December, 1960 issue of "Geophysics")

ocated in all active oil areas, Mayhew ssures you of continuous operation with a complete line of supplies and replacement parts. So wherever you are located contact your convenient Mayhew Supply Store . . . You get the most with a Mayhew!

HOME OFFICE	**MAYHEW SUPPLY CO., INC.** 4700 SCYENE ROAD • DALLAS, TEXAS
SALES AND SERVICE	CASPER, WYOMING • TULSA, OKLAHOMA • SIDNEY, MONTANA • ODESSA, TEXAS • GRAND JUNCTION, COLORADO JACKSON, MISS. • HOUSTON, TEXAS
CANADA	SEISMIC SERVICE SUPPLY, LTD., CALGARY AND EDMONTON, ALBERTA
EXPORT	GARDNER-DENVER INTERNATIONAL DIV. NEW YORK, N. Y.

Standard of the Industry

GEOPHYSICAL SOCIETY OF TULSA

ACTIVE MEMBERSHIP ROLL

AS OF JULY 5, 1961

Karl W. Abel	Mayes-Bevan Co.	
	305 Kennedy Bldg.	Tulsa, Okla
Robert Hunter Adams	Union Oil Company of Calif.	
	1812 1st Natl. Bank Bldg.	Tulsa 3, Okla.
Warren A. Alexander	Jersey Production Research Co.	
	1133 N. Lewis Ave.	Tulsa 10, Okla.
R. M. Allyn	408 B Lannom Bldg.	Bartlesville, Okla.
Maurice E. Arnold, Jr.	Box 591	Tulsa 2, Okla.
Tapley G. Arnold	Geo-Seis, Inc.	
	515 Thompson Bldg.	Tulsa 3, Okla.
W. H. Audley	Pohly Exploration	
	1135 E. 38th	Tulsa 5, Okla.
A. C. Austin	P. O. Box 1309	Casper, Wyoming
C. T. Austin	Texaco Inc.	
	P. O. Box 2420	Tulsa 1, Okla.
Karl E. Baer	3745 E. 39th Pl.	Tulsa 5, Okla.
John T. Baker	5342 E. 30th St.	Tulsa 14, Okla.
James A. Ballard	Cardinal Geophysical Co., Inc.	
	822 Union Center	Wichita, Kansas
Albert L. Ballou, Jr.	9 E. Fourth	Tulsa 3, Okla.
Robert W. Baltosser	Route #3	Broken Arrow, Okla.
A. J. Barthelmes	Seismograph Service Corp.	
	Box 1590	Tulsa 1, Okla.
Bert L. Bass	Texaco Inc.	
	P. O. Box 2420	Tulsa 2, Okla.
Robert B. Baum	Seismograph Service Corp.	
	1229 Texas Nat'l Bank Bldg.	Houston 2, Texas
Joseph F. Bayhi	Jersey Production Research Company	
	1133 N. Lewis Ave.	Tulsa 10, Okla.
R. E. Beck	Phillips Petroleum Co.	
	7th Floor Adams Bldg.	Bartlesville, Okla.
Arthur D. Bennett	Pan American Petroleum Corp.	
	P. O. Box 591	Tulsa 2, Okla.
N. James Bentley-Llewellyn	Century Geophysical Corporation	
	1333 N. Utica	Tulsa 10, Okla.
Louis L. Bergan	1623 S. Rogers	Bartlesville, Okla.
Lucille Berlin	Supervisor of Science	
	3027 S. New Haven	Tulsa 14, Okla.
Donald L. Berry	4724 Cornell Dr.	Bartlesville, Okla.
Thomas J. Bevan	914 American Airlines Bldg.	Tulsa, Okla.
Peter Bike	Oil & Gas Journal	
	211 S. Cheyenne	Tulsa 3, Okla.

Daryl E. Birnie	Pan American Petroleum Corp. 41st and Yale	Tulsa 5, Okla.
Bruce A. Blackman	4121 E. 48th Pl.	Tulsa 5, Okla.
J. R. Blaisdell	Seismograph Service Corp. P. O. Box 1590	Tulsa 1, Okla.
Carl W. Blakey	Century Geophysical Corp. Jenkins Bldg.—515 S. Main	Tulsa 3, Okla.
J. E. Bondurant	400 W. Frank Phillips Blvd.	Bartlesville, Okla.
Ibrey T. Bonnette	3916 E. 1st St.	Tulsa 12, Okla.
Frank W. Borman	Amerada Petroleum Corp. Box 2040	Tulsa 2, Okla.
W. T. Born	136 Mohawk Blvd.	Tulsa 6, Okla.
F. G. Boucher	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Charles P. Bowditch	3424 E. 56th Pl. South	Tulsa 5, Okla.
D. C. Bowman	620 S. 91st E. Ave.	Tulsa 15, Okla.
Robert B. Bradley	2745 S. Gary Dr.	Tulsa 5, Okla.
Frank Branisa	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Curtis C. Bratt	Phillips Petroleum Co. Rm 416, 1st Nat'l Bank Bldg.	Bartlesville, Okla.
Theodor H. Braun	538 Mission St.	South Pasadena, Calif.
Howard R. Breck	2912 E. 26th St.	Tulsa 14, Okla.
W. B. Brinnon	Box 1650	Tulsa 2, Okla.
R. A. Broding	2820 E. 39th St.	Tulsa 5, Okla.
Charles C. Brooks	P. O. Box 2208	Tulsa 1, Okla.
W. M. Brooks	4569 S. Jamestown	Tulsa 5, Okla.
Frank E. Brown	P. O. Box 2208	Tulsa, Okla.
Graydon L. Brown	2100 John St.	Ponca City, Okla.
Richard W. Brown	200 Koppel Bldg.	Bartlesville, Okla.
Charles A. Bucklin	2664 S. Sandusky	Tulsa 15, Okla.
Robert L. Bucknell	313½ S. Osage	Bartlesville, Okla.
C. E. Buffum	Pan American Petroleum Corp. P. O. Box 591	Tulsa 1, Okla.
J. W. Burk	c/o The Pure Oil Company P. O. Box 1611	Casper, Wyoming
Ernest D. Burkett	Seismograph Service Corp. Box 1590	Tulsa 1, Okla.
Kay N. Burns	1770 W. Fairview St.	Tulsa 15, Okla.
William W. Burress	Sinclair Research Lab P. O. Box 3006, Whittier Station	Tulsa 8, Okla.
Robert Burton	4956 E. 26th St.	Tulsa 14, Okla.
Charles L. Bury	Box 1590	Tulsa 1, Okla.
W. W. Butler	Tidewater Oil Company Box 731	Tulsa 2, Okla.
Ray L. Calkins	7456 E. 30th St.	Tulsa 14, Okla.
Colin C. Campbell	P. O. Box 1536	Tulsa 1, Okla.

SPECIAL LOGGING ISSUE REPRINTED

AUGUST 1960 GEOPHYSICS

This special issue, edited by G. E. Archie, and containing nine outstanding logging papers from the 1959 Los Angeles symposium, has been reprinted in response to popular demand.

Includes examples of staff organization, discussion of physiochemical properties of rocks, interpretation of sandstone and limestone conditions, and descriptions or specific types of surveys. Also covers use of logging tools for well completion and workover.

A must *FOR EVERY EXPLORATION LIBRARY*

$3.00 per copy ($2.50 to SEG members)
(Add 20 cents per copy on foreign orders)

SOCIETY OF EXPLORATION GEOPHYSICISTS

913 Shell Building Tulsa 19, Oklahoma

Francis F. Campbell	Amerada Petroleum Corporation Box 2040	Tulsa 1, Okla.
Gerald L. Canfield	Amerada Petroleum Corporation P. O. Box 2040	Tulsa 1, Okla.
John L. Care	Seis-Tech Exploration Company 1316 Union Nat'l Bldg.	Wichita, Kansas
W. A. Carruth	Box 2040	Tulsa, Okla.
J. L. Casey	P. O. Box 2656	Tulsa 1, Okla.
R. F. Christy	Shell Oil Company Box 1191	Tulsa, Okla.
R. C. Clark	Humble Oil & Refining Co. P. O. Box 801	Tulsa, Okla.
Frank Clynch	c/o Continental Oil Co.	Ponca City, Okla.
David W. Cochrane	Box 1590	Tulsa 1, Okla.
R. Clare Coffin	Pan American Petroleum Corp. P. O. Box 591	Tulsa 1, Okla.
John J. Collier	The Pure Oil Company Box 271	Tulsa 2, Okla.
J. E. Connell	Box 2040	Tulsa, Okla.
J. A. Cooley	1611 S. Main St.	Tulsa 19, Okla.
Jack R. Cooper	Pan American Petroleum Corp. Box 591 (Research Center)	Tulsa 1, Okla.
C. W. Conley	400 W. Frank Phillips Blvd.	Bartlesville, Okla.
D. G. Corbin	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
William H. Courtier	Phillips Petroleum Co.	Bartlesville, Okla.
James R. Cox	1215 S. Indianapolis	Tulsa 12, Okla.
Mitchell Cox	Central High School	Bartlesville, Okla.
Marion Cracraft	The Tulsa Tribune Box 1770	Tulsa 3, Okla.
Clifton C. Crawford	Amerada Petroleum Corporation P. O. Box 2040	Tulsa 1, Okla.
John M. Crawford	Development & Research Dept. Continental Oil Company	Ponca City, Okla.
Kenneth S. Cressman	c/o Amerada Petroleum Corp. P. O. Box 2040	Tulsa 2, Okla.
Kenneth C. Crumrine	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
William J. Cunningham	4410 E. 35th St.	Tulsa 5, Okla.
Carl E. Davidson	1234 N. Wyandotte	Dewey, Okla.
Edward Markham Davin	Jersey Research 1133 N. Lewis Ave.	Tulsa 10, Okla.
Johnnie C. Davis	2903 S. Hudson	Tulsa 14, Okla.
Dallas R. Davis	5110 E. 15th St.	Tulsa 12, Okla.
Charles E. Day	Geophysical Research Corp. 136 E. Mohawk Blvd.	Tulsa 6, Okla.
E. J. Denadel	Head, Science Department College High School	Bartlesville, Okla.

K. P. Desai	P. O. Box 1590	Tulsa 2, Okla.
Raymond G. De Verse	4158 E. 38th St.	Tulsa 15, Okla.
Ronald E. Diederich	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Opie Dimmick	Century Geophysical Corp. Jenkins Bldg., 515 S. Main	Tulsa 3, Okla.
William E. N. Doty	Continental Oil Company Drawer 1267	Ponca City, Okla.
Mrs. Louise Duerksen	Central High School	Bartlesville, Okla.
C. P. Durant	4436 E. 38th St.	Tulsa 5, Okla.
Karl Dyk	Pan American Petroleum Corp. P. O. Box 591	Tulsa 1, Okla.
James Calvin Earthman	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
S. D. Elliott	Phillips Petroleum Company 400 W. Frank Phillips Blvd.	Bartlesville, Okla.
Sheldon E. Elliott	329 S. Ponca	Dewey, Okla.
W. H. Elson, Jr.	305 Midcontinent Bldg.	Tulsa 3, Okla.
William M. Erdahl	Skelly Oil Company Box 1650	Tulsa, Okla.
Harry S. Eshelman	2448 S. Joplin	Tulsa 14, Okla.
Julian F. Evans	Pan American Petroleum Corp. P. O. Box 591	Tulsa 1, Okla.
Delbert W. Fair	417 S. 12th St.	Ponca City, Okla.
L. Y. Faust	Amerada Petroleum Corporation Box 2040	Tulsa, Okla.
George F. Ferguson	4127 S. Sandusky	Tulsa 5, Okla.
John L. Ferguson	3534 S. Zunis Pl.	Tulsa 5, Okla.
Joseph Waverly Ferguson, Jr.	P. O. Box 1590	Tulsa 2, Okla.
Paul M. Ferguson	5406 E. 24th St.	Tulsa 14, Okla.
Craig Ferris	1243 E. 28th St.	Tulsa 5, Okla.
John W. Fetrow	Geophysical Lab. - Conoco	Ponca City, Okla.
Clinton Fewell	4214 E. 40th Pl.	Tulsa 35, Okla.
Harold S. Field	Geophysical Research Corporation 136 Mohawk Blvd.	Tulsa 6, Okla.
W. L. Field	4412 E. Frank Phillips Blvd.	Bartlesville, Okla.
Jerry Fillebrown	704 N. Xanthus	Tulsa 10, Okla.
R. K. Finley	1218 S. Vandalia	Tulsa 12, Okla.
Robert S. Finn	Seismograph Service Corporation P. O. Box 1590	Tulsa 1, Okla.
J. L. Fisher	3318 E. King St.	Tulsa 15, Okla.
Robert B. Fisher	Davis Equipment, Inc. 5110 E. 15th St.	Tulsa 12, Okla.
Hubert E. Flury		Jenks, Oklahoma
Lloyd C. Fonns	Seismograph Service Corporation P. O. Box 1590	Tulsa 1, Okla.
Robert D. Forester	Box 591	Tulsa 2, Okla.
Kenneth Frakes	8835 Birdwood	Houston, Texas

John V. Franklin	The Atlantic Refining Company 2915 Classen Blvd. Okla. City 6, Okla.
Orville H. Frazier	Amerada Petroleum Corporation Box 2040 Tulsa, Okla.
F. Ray Freeman	3745 E. 3rd St. Tulsa 12, Okla.
Francis C. French	830 Kennedy Bldg. Tulsa 3, Okla.
Everett L. Erickson	Continental Oil Company P. O. Drawer 1267 Ponca City, Okla.
Jack L. Friendly	515 Jenkins Bldg. Tulsa 3, Okla.
R. L. Frossard	Sinclair Oil & Gas Company Box 521 Tulsa 2, Okla.
Noel Frost	Box 1590 Tulsa 1, Okla.
Thomas K. Fulton	5111 E. 29th St. Tulsa 14, Okla.
W. H. Gage	c/o Seismograph Service Corporation P. O. Box 1590 Tulsa 1, Okla.
V. U. Gaither	Continental Oil Company Drawer 1267 Ponca City, Okla.
Frank J. Gardner	Oil & Gas Journal Box 1260 Tulsa 1, Okla.
J. P. Garner	Tulsa Exploration Company 501 Oil Capital Bldg. Tulsa, Okla.
F. I. Garrette	Box 1590 Tulsa 1, Okla.
Roy E. Garten, Jr.	Continental Oil Company Drawer 1267 Ponca City, Okla.
Robert L. Geyer	5613 S. Pittsburg Ave. Tulsa 5, Okla.
Fred Gillig	c/o Ohio Oil Company 6th Floor, Enterprise Bldg. Tulsa 3, Okla.
Andrew Gilmour	4417 S. Lewis Tulsa 5, Okla.
S. E. Giulio	Jersey Production Research Company 1133 N. Lewis Ave. Tulsa 10, Okla.
Wayne B. Goodenow	1513 El Camino Ponca City, Okla.
Pierre L. Goupillaud	909 S. 8th Ponca City, Okla.
Victor V. Graf	Seismograph Service Corporation Box 1590 Tulsa 2, Okla.
M. S. Graham	P. O. Box 2212 Casper, Wyoming
G. C. Green	Oil Capitol Electronics Corp. 923 E. 4th Tulsa 10, Okla.
Joe W. Green	P. O. Box 15799, Admiral Sta. Tulsa 9, Okla.
R. P. Green	Republic Exploration Company Box 2208 Tulsa 2, Okla.
T. S. Green	Geo Prospectors, Inc. Box 9577 Tulsa 7, Okla.
S. L. Grimes	Phillips Petroleum Company 407 A Lannom Bldg. Bartlesville, Okla.
W. H. Guyton	411 Lannom Bldg. 122½ Frank Phillips Blvd. Bartlesville, Okla.
Charles F. Hadley	Pan American Petroleum Corporation P. O. Box 591 Tulsa 1, Okla.

T. A. Halbrook	3740 E. 47th Pl.	Tulsa 5, Okla.
Baylora Duke Hull	3030 S. Detroit	Tulsa 14, Okla.
C. E. Hallock	P. O. Box 521	Tulsa 1, Okla.
Dr. William Hambleton	Department of Geology University of Kansas	Lawrence, Kansas
Dr. Sigmund Hammer	Gulf Research & Development Company Box 2038	Pittsburgh 30, Pa.
J. W. Hammond	5525 S. Toledo Pl.	Tulsa 2, Okla.
Bruce H. Harlton	Amerada Petroleum Corporation Box 2040	Tulsa, Okla.
Delbert Ray Harper	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
James C. Harper	3446 S. Zunis	Tulsa 5, Okla.
Robert M. Hart	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Royal A. Hartenberger	365 S.E. Elmhurst	Bartlesville, Okla.
Ralph E. Hartline	1943 S. College	Tulsa 4, Okla.
James E. Hawkins	Seismograph Service Corporation Box 1590	Tulsa, Okla.
F. M. Hawpe	4635 E. 13th Pl.	Tulsa 12, Okla.
W. O. Heap	Box 1590	Tulsa 1, Okla.
Billy J. Heath	Continental Oil Company Drawer 1267	Ponca City, Okla.
C. E. Hendricks	5500 E. 51st St., R. R.. #7	Tulsa, Okla.
Haines C. Hibbard	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
W. E. Hightower	Geo. Prospectors, Inc. Box 9577	Tulsa 7, Okla.
Charles F. Hinrichs	Phillips Petroleum Company 200 Koppel Blvd.	Bartlesville, Okla.
A. J. Hintze	Phillips Petroleum Co.	Bartlesville, Okla.
Lorimer W. Hoar	4126 E. 35th Pl.	Tulsa 15, Okla.
Henry Hobart, Jr.	1539 E. 54th Pl.	Tulsa 5, Okla.
John M. Horeth	2431 S. Pittsburg	Tulsa 5, Okla.
A. Maxwell House	Geo Prospectors, Inc. Box 9577	Tulsa 7, Okla.
Victor H. Howard, Jr.	Sinclair Oil & Gas Company Box 521	Tulsa, Okla.
S. Grace Hower	Amerada Petroleum Corporation Box 2040	Tulsa 2, Okla.
Thomas P. Hubbard, Jr.	1140 S. Gary	Tulsa 4, Okla.
Roland F. Hughes	915 N. 3rd St.	Ponca City, Okla.
C. R. Humphrey	Seisdrill, Inc. 515 Thompson Bldg.	Tulsa 3, Okla.
M. R. Hundley	c/o Phillips Petroleum Company 414 Bank Bldg.	Bartlesville, Okla.
James R. Hunt	2140 E. 19th St.	Tulsa 4, Okla.

Clare Hurry	Humble Oil & Refining Company Box 801	Tulsa, Okla.
Clyde V. Hussey	Seismograph Service Corporation Box 1590	Tulsa 2, Okla.
John S. Hutchison	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
A. E. Ibach	Aero Service Corporation 1401 S. Detroit	Tulsa 20, Okla.
Arland I. Innes	Amerada Petroleum Corporation Box 2040	Tulsa, Okla.
Judson G. Jackson	Seismograph Service Corporation Box 1590	Tulsa, Okla.
Peter Jacobsen, Jr.	1133 N. Lewis Ave.	Tulsa 10, Okla.
Chet H. Jameson, Jr.	414 Enterprise Bldg.	Tulsa 3, Okla.
Lorenzo E. Jarrett, Jr.	1202 S. 7th St.	Ponca City, Okla.
Vincent F. Jenneman	P. O. Box 591	Tulsa 2, Okla.
D. F. Jewell, Jr.	1741 S. Fulton	Tulsa 12, Okla.
Harry C. Johnsen	Phillips Petroleum Company 400 W. Frank Phillips	Bartlesville, Okla.
Julius H. Johnson	3104 E. Latimer Pl.	Tulsa 15, Okla.
James F. Johnson	Sinclair Research Labs., Inc. Box 3006, Whittier Sta.	Tulsa 8, Okla.
E. W. Johnson	1624 Arbor Dr.	Bartlesville, Okla.
Thomas E. Johnson	Apartado 1031	Caracas, Venezuela
Virgil R. Johnson	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
R. N. Jolly	3908 E. 31st St.	Tulsa 15, Okla.
Joe H. Jones	Sinclair Research Labs., Inc. Box 3006, Whittier Sta.	Tulsa 8, Okla.
V. L. Jones	1412 S. Norfolk	Tulsa 20, Okla.
Elzie A. Kee	Phillips Petroleum Company 416 Bank Bldg.	Bartlesville, Okla.
Joseph W. Keffler	5004 Harvard	Bartlesville, Okla.
Benny H. Keller	1412 S. Winston	Tulsa 12, Okla.
Vern Kidd	P. O. Box 15799, Admiral Sta.	Tulsa 9, Okla.
Laurence K. King	Continental Oil Company Box 1267	Ponca City, Okla.
Robert A. Kirby	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Frank R. Kittredge	Sinclair Oil & Gas Company P. O. Box 521	Tulsa 2, Okla.
J. G. Knowles	c/o E. V. McCollum & Co. 515 Thompson Bldg.	Tulsa 3, Okla.
A. J. Kochendorfer	Box 1590	Tulsa 2, Okla.
B. W. Koeppel	Lorac Service Corp. P. O. Box 1590	Tulsa 1, Okla.
James W. Kugler	Davis Equipment Company 5110 E. 15th St.	Tulsa 12, Okla.

J. P. Lamb	P. O. Box 2656	Tulsa 1, Okla.
William C. Lamb	Gulf Oil Corporation P. O. Box 910	Coral Gables 34, Fla.
John P. Lambe	7486 E. 30th St.	Tulsa 5, Okla.
Ralph A. Landrum	7449 E. 30th St.	Tulsa 14, Okla.
Harold M. Lang	Pan American Petroleum Corporation P. O. Box 591	Tulsa 1, Okla.
Charles C. Lash	Pan American Petroleum Corporation P. O. Box 591	Tulsa 1, Okla.
William F. Latting, Jr.	Society of Exploration Geophysicists Box 1536	Tulsa 1, Okla.
A. L. Laughry	Phillips Petroleum Company 400 W. Frank Phillips Blvd.	Bartlesville, Okla.
Franklin L. Lawrence	7374 E. 25th Pl.	Tulsa 29, Okla.
Homer W. Lawrence	Seismograph Service Corporation Box 1590	Tulsa 1, Okla.
K. M. Lawrence	Amerada Petroleum Corporation Box 2040	Tulsa, Okla.
Milford R. Lee	8 Lake Road	Ponca City, Okla.
Franklin K. Levin	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
E. B. Lindsey	Seismograph Service Corporation Box 1590	Tulsa 1, Okla.
J. P. Lindsey	Phillips Petroleum Company CL-PRC 187	Bartlesville, Okla.
Harry J. Lins	Seismograph Service Corporation Box 1590	Tulsa 2, Okla.
George W. Lisle	4136 S. Trenton	Tulsa 5, Okla.
W. K. Litson	Seismograph Service Corporation Box 1590	Tulsa, Okla.
L. F. Lockard	Sinclair Oil & Gas Company Box 521	Tulsa 2, Okla.
Ralph C. Loring	953 Yale Dr.	Bartlesville, Okla.
C. C. Ludwick	Shell Oil Company 1700 Broadway	Denver 2, Colo.
H. A. Lukowitch	Geo. Prospectors, Inc. Box 9577	Tulsa 7, Okla.
James T. Lynch	2610 S. Birmingham Pl.	Tulsa 14, Okla.
Ralph D. Lynn	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Paul L. Lyons	Sinclair Oil & Gas Company P. O. Box 521	Tulsa 2, Okla.
Arthur C. Magill	813 Fostoria Lane	Houston 9, Texas
T. A. Manhart	P. O. Box 6216	Tulsa 17, Okla.
J. E. Maritt	1724 Dewey Ave.	Bartlesville, Okla.
James L. Martin, Jr.	Sinclair Oil & Gas Company P. O. Box 521	Tulsa 2, Okla.

Samuel T. Martner	Pan American Petroleum Corporation P. O. Box 591	Tulsa 1, Okla.
R. L. Mathieson	1015 S. College	Tulsa, Okla.
Thomas E. Matson	231 E. 20th St.	Tulsa 20, Okla.
J. R. Maxey	3804 S. St. Louis	Tulsa 5, Okla.
Tom D. Mayes	Mayes-Bevan Company Kennedy Bldg.	Tulsa, Okla.
C. H. McAlister	Box 4296	Tulsa 9, Okla.
Charles D. McAlister	1133 N. Lewis	Tulsa 10, Okla.
P. D. McCalman	P. O. Box 1590	Tulsa, Okla.
Ed. R. McCarter	5820 E. 23rd St.	Tulsa 14, Okla.
John C. McCaslin	Box 1260	Tulsa, Okla.
E. V. McCollum	515 Thompson Bldg.	Tulsa, Okla.
Max D. McCormick	2530 S. Cincinnati	Tulsa 14, Okla.
Benjamin F. McCoy	146 N. Delaware Pl.	Tulsa 4, Okla.
Leroy McCravey	The Texas Company Box 2420	Tulsa 2, Okla.
P. M. McNally	Phillips Petroleum Company 416 Bank Bldg.	Bartlesville, Okla.
E. M. McNatt	Room 2736 30 Rockfeller Plaza	New York 20, New York
Barton F. McPherson	422 N. Main	Tulsa 3, Okla.
Frederic H. Meister	807-B N. Osage Dr.	Tulsa 6, Okla.
H. L. Mendenhall	Phillips Petroleum Company 416 Bank Bldg.	Bartlesville, Okla.
Joseph F. Mifsud	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Sheldon M. Miller	1403 E. 5th Ct.	Tulsa 20, Okla.
Vincent Miller	Box 1289	Bartlesville, Okla.
Wallace R. Miller	Humble Oil & Refining Company Box 801	Tulsa 2, Okla.
Robert G. Mills	Precision Exploration Company 310 Enterprise Bldg.	Tulsa 3, Okla.
Young O. Mitchell	Tulsa World P. O. Box 1170	Tulsa 2, Okla.
Joseph P. Molenaar	Sun Oil Company P. O. Box 1348	Tulsa 1, Okla.
H. T. Monholland	3470 S. Zunis	Tulsa 5, Okla.
William L. Monroe	201 Parkview Dr.	Bartlesville, Okla.
Homer C. Moore	313 Oil Capital Bldg.	Tulsa 3, Okla.
N. K. Moody	Seismograph Service Corporation Box 1590	Tulsa 2, Okla.
Floyd H. Morris	414 First Nat'l Bank Bldg.	Bartlesville, Okla.
Gerald B. Morris	1133 N. Lewis	Tulsa 10, Okla.
Lawrence S. Morrison	Humble Oil & Refining Company	Ardmore, Okla.
G. Robert Morrow	Midwestern Instruments, Inc. P. O. Box 7509	Tulsa 18, Okla.

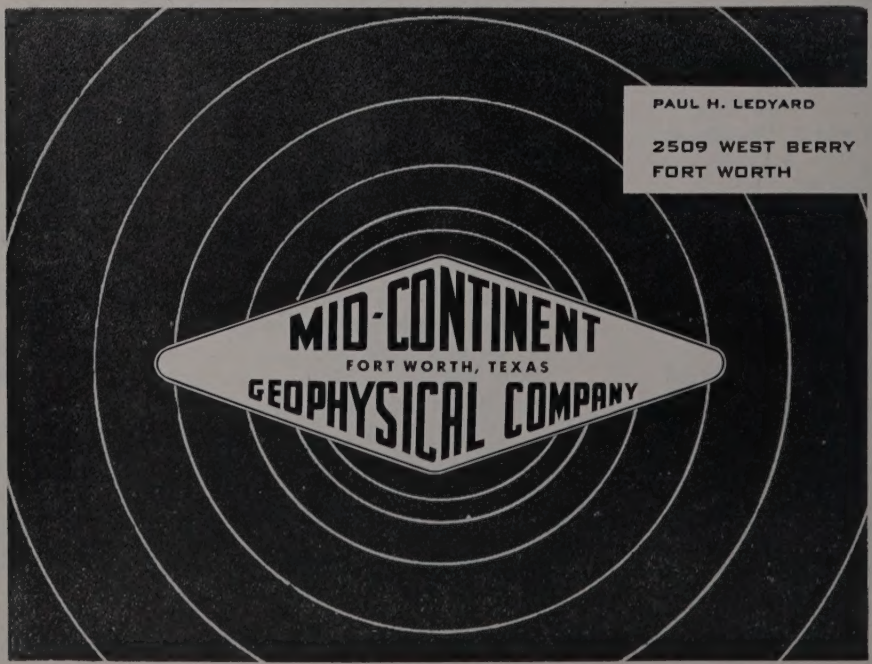
M. E. Morrow	Midwestern Instruments, Inc. P. O. Box 7509	Tulsa 18, Okla.
R. W. Mossman	Seismograph Service Corporation Box 1590	Tulsa, Okla.
C. S. Moynihan	Sun Oil Company P. O. Box 1348	Tulsa 2, Okla.
James M. Murphy	1859 S. Armstrong	Bartlesville, Okla.
Walter I. Myers	Smith & Myers 1425 S. Main St.	Tulsa 19, Okla.
Bert F. Nally, Jr.	6752 E. Independence St.	Tulsa, Okla.
James R. New	Consolidated Geophysical Surveys 212 Court Arcade Bldg.	Tulsa 3, Okla.
James W. Newell	2641 S. 74th East Ave.	Tulsa 5, Okla.
George R. Newton	1908 E. 38th St.	Tulsa 5, Okla.
Jack A. Noble	Sunray Mid-Continent Oil Company 907 S. Detroit	Tulsa 20, Okla.
John Norris	1914 S. College	Tulsa 4, Okla.
Walter O. Novelly	Republic Exploration Company Box 2208	Tulsa 1, Okla.
Donald R. Oksa	5904 E. King Pl.	Tulsa 15, Okla.
Charles W. Oliphant	1905 Nat'l Bank of Tulsa Bldg.	Tulsa 3, Okla.
Joseph J. O'Neill	Sinclair Research Labs 860 N. Lewis	Tulsa 10, Okla.
Howard Oshry	Well Surveys, Inc. Box 2656	Tulsa 1, Okla.
H. E. Owen	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
John E. Owen	2607 N. Boston Pl.	Tulsa 6, Okla.
David S. Paige	Phillips Petroleum Company 418 Bank Bldg.	Bartlesville, Okla.
J. E. Palmer	4311 E. 56th Pl.	Tulsa 5, Okla.
Curtis L. Peet, Jr.	1445 S. Hickory	Bartlesville, Okla.
W. E. Pennington	Amerada Petroleum Corporation Box 2040	Tulsa 2, Okla.
C. D. Pentecost	4630 S. Columbia Ave.	Tulsa 5, Okla.
Charles C. Perry, Jr.	Seismograph Service Corporation P. O. Box 1590	Tulsa 1, Okla.
W. B. Perry	Geo. Prospectors, Inc. Box 9577	Tulsa 7, Okla.
V. A. Peterson	P. O. Box 521	Tulsa, Okla.
Raymond G. Piety	504 Cherokee Ave.	Bartlesville, Okla.
Richard D. Pittenger	Jersey Production Research Company 1133 N. Lewis	Tulsa 10, Okla.
Ross L. Pittman	1705 Blackard Lane	Ponca City, Okla.
Jack W. Poe	2706 S. Sheridan Rd.	Tulsa 14, Okla.
Richard A. Pohly	Box 7066	Tulsa 18, Okla.
Delbert E. Potter	2814 S. Pittsburg	Tulsa 14, Okla.

Newell Pottorf	1707 E. 14th St.	Tulsa 4, Okla.
M. Darwin Quigley	English Oil Company 366 S. 5th East	Salt Lake City, Utah
Marshall P. Ragan	1135 S. Birmingham	Tulsa 4, Okla.
David E. Reed	Box 2239	Tulsa 1, Okla.
George W. Reed	2502 E. Admiral Pl.	Tulsa 10, Okla.
W. A. Reeves	Tidewater Company Box 1404	Houston 1, Texas
Wesley W. Rees	305 Kennedy Bldg.	Tulsa 3, Okla.
A. C. Reid	1718 S. Delaware Pl.	Tulsa, Okla.
W. E. Richardson	1928 Joe St.	Ponca City, Okla.
Dr. Norman Ricker	University of Oklahoma Physics Department	Norman, Okla.
James J. Roark	1218 S. Darlington	Tulsa 4, Okla
George L. Robb	4341 E. 28th St.	Tulsa 14, Okla
Frederick A. Roberts	1416 E. 17th Pl.	Tulsa 20, Okla
Price E. Roberts	Tulsa Exploration Co., Inc. 501 Oil Capital Bldg.	Tulsa 3, Okla.
Van Roberts	Box 1590	Tulsa, Okla.
K. A. Robertson	Precision Exploration Company 310 Enterprise Bldg.	Tulsa 3, Okla.
Donald J. Robinson	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Walter R. Robinson, Jr.	4191 E. 46th St.	Tulsa 5, Okla.
Edward O. Roe	3805 E. Independence	Tulsa 4, Okla.
Cletus D. Roemer	Consolidated Geophysical Surveys 212 Court Arcade Bldg.	Tulsa 3, Okla.
Robert C. Roesch	Amerada Petroleum Corporation Box 2040	Tulsa 2, Okla.
J. C. "Bill" Rollins	Phillips Petroleum Company 416 Bank Bldg.	Bartlesville, Okla.
Marvin Romberg	Humble Oil & Refining Company Box 801	Tulsa 2, Okla.
Ben Rummerfield	6787 Timberlane Dr.	Tulsa 10, Okla.
John J. Rupnik	730 Beacon Bldg.	Tulsa 3, Okla.
John Sage	4406 E. 24th St.	Tulsa 14, Okla.
Robert W. Saubert	Box 1590	Tulsa 1, Okla.
Richard M. Scharlock	Humble Oil & Refining Company P. O. Box 801	Tulsa 2, Okla.
Edw. G. Schempf	310 Enterprise Bldg.	Tulsa 3, Okla.
Alvin J. Schisler	2431 S. Troost	Tulsa 14, Okla.
S. Wm. Schoellhorn	Seismograph Service Corporation P. O. Box 1590	Tulsa 1, Okla.
Charles N. Scott	1800 Arbor Dr.	Bartlesville, Okla.
Frank Searcy	Drawer 1267	Ponca City, Okla.
Robert M. See	Geophysical Section Continental Oil Co.	Ponca City, Okla.

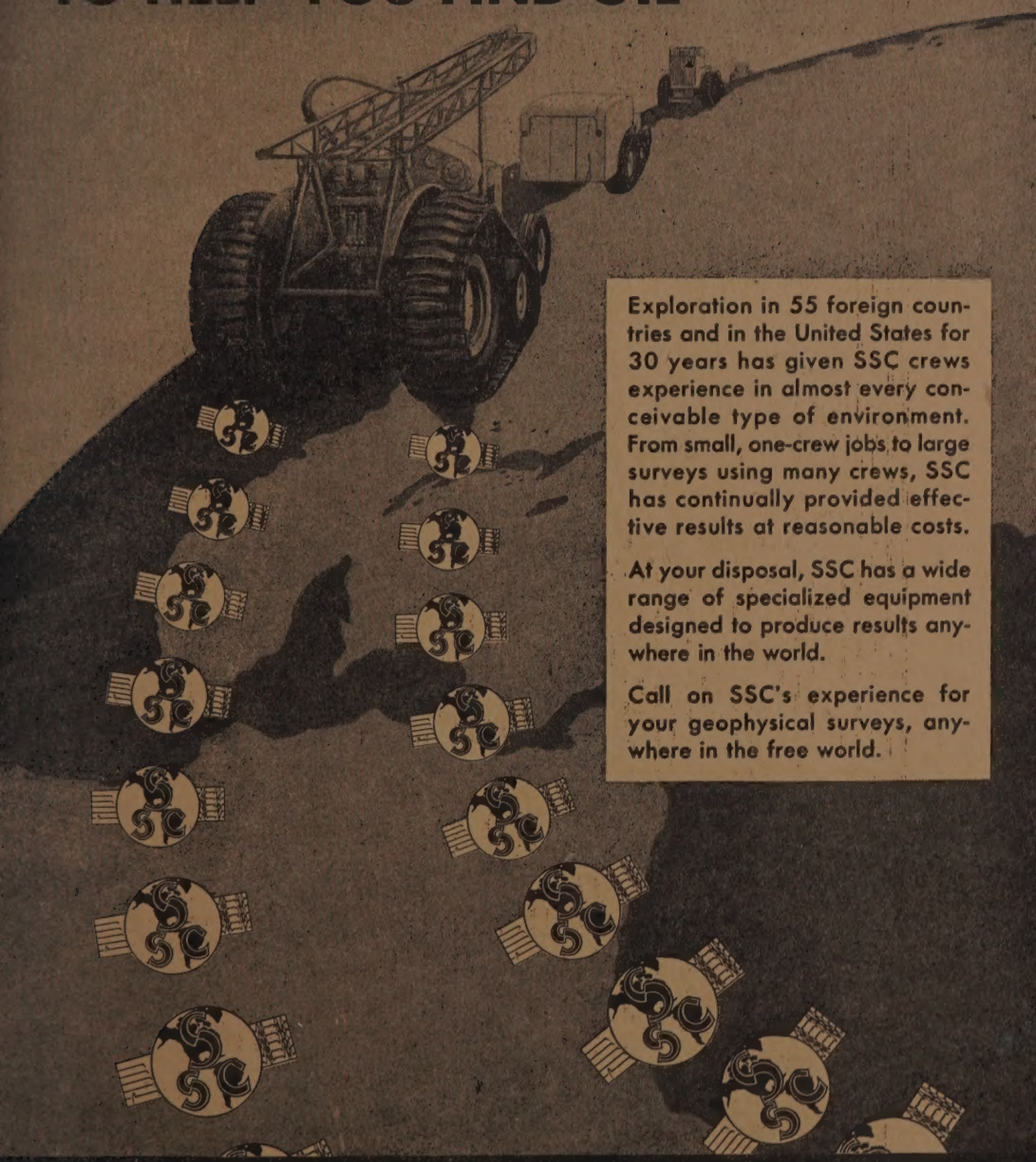
G. B. Seeburger	Pohly Exploration Company P. O. Box 7066	Tulsa 9, Okla.
William K. Shack	1613 Oklahoma St.	Bartlesville, Okla.
G. Newman Shell	Cities Service Oil Co.	Bartlesville, Okla.
Gerald J. Shimer	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Daniel Silverman	P. O. Box 591	Tulsa 1, Okla.
J. D. Skelton	5124 E. 23rd St.	Tulsa 14, Okla.
Warren H. Smith	Box 2420	Tulsa 1, Okla.
William H. Smith	Phillips Petroleum Company 405 Lannom Bldg.	Bartlesville, Okla.
W. N. Smith	Smith & Myers 1425 S. Main St.	Tulsa 19, Okla.
Allan D. Sontag	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
William A. Sorge	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Tom F. Southgate	Amerada Petroleum Corporation Box 2040	Tulsa, Okla.
Neil R. Sparks	Pan American Petroleum Corporation P. O. Box 591	Tulsa 1, Okla.
Jerry M. Speers	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
James T. Stark	Box 824	Bartlesville, Okla.
William J. Stark	3803 E. 9th St.	Tulsa 20, Okla.
Paul Harris Steed	212 Court Arcade Bldg.	Tulsa 3, Okla.
M. Grady Steil	P. O. Box 1590	Tulsa, Okla.
Don G. Sterry	Phillips Petroleum Company Room 185 - Chem. Lab.	Bartlesville, Okla.
J. Eugene Stones	Lion Oil Div., Monsanto Chem. Co. Box 1829	Midland, Texas
Dean Stover	Pan American Petroleum Corporation 41st & Yale	Tulsa 5, Okla.
Edward B. Stover, Jr.	Box 591	Tulsa, Okla.
Clyde G. Strachan	1712 S. Troost	Tulsa 20, Okla.
William H. Strickland	P. O. Box 1191	Tulsa 1, Okla.
Wilton O. Stubbs	1648 S. Maple	Bartlesville, Okla.
Gilbert Swift	Well Surveys, Inc. Box 2656	Tulsa 2, Okla.
Albert W. Taylor	Box 2040	Tulsa, Okla.
M. O. Teufel	209 S. Walnut St.	Newkirk, Okla.
T. J. Thomas	Sunray Mid-Continent Oil Company P. O. Box 2039	Tulsa 2, Okla.
Kieran J. Thompson	P. O. Box 2040	Tulsa 2, Okla.
H. M. Thralls	Geo. Prospectors, Inc. Box 9577	Tulsa 7, Okla.
Bert C. Timm	P. O. Box 2039	Tulsa 2, Okla.
Kenneth S. Townsend	4422 W. Easton Pl.	Tulsa 27, Okla.

Paul M. Tucker	Humble Oil & Refining Company P. O. Box 801	Tulsa 2, Okla.
R. H. Tucker	Cities Service Oil Co.	Bartlesville, Okla.
E. W. Turnbough	The Texas Company Box 2420	Tulsa 2, Okla.
Gordon Tyler	Gordon Tyler Company 703 Oil Capitol Bldg.	Tulsa 3, Okla.
Ronald L. Ulrich	542 S. 105 Pl. East	Tulsa 28, Okla.
Jerry E. Upp	1548 S. College	Tulsa 4, Okla.
Eugene Usdin	Southwestern Computing Service 910 S. Boston	Tulsa 19, Okla.
Ray B. Vandeventer	3738 E. 2nd Pl.	Tulsa 12, Okla.
Hector A. Van Buskirk	2502 E. 21st St.	Tulsa 14, Okla.
W. H. Van Horn	Seismograph Service Corporation P. O. Box 1590	Tulsa 1, Okla.
Stefan Von Croy	Sunray Mid-Continent Oil Company P. O. Box 2039	Tulsa 2, Okla.
S. K. Van Steenbergh	P. O. Box 521	Tulsa 1, Okla.
H. A. Wakefield	Continental Oil Company Geophysical Lab.	Ponca City, Okla.
H. B. Walz	Phillips Petroleum Company 416 Bank Bldg.	Bartlesville, Okla.
H. B. Warren	International Drilling Company 314 Enterprise Bldg.	Tulsa 3, Okla.
Kenneth H. Waters	Continental Oil Company Drawer 1267	Ponca City, Okla.
Robert J. Watson	Humble Oil Refining Company P. O. Box 801	Tulsa 2, Okla.
Dr. B. B. Weatherby	Box 2040	Tulsa 2, Okla.
Kenneth A. Webb	Seismic Explorations, Inc. P. O. Box 6248	Houston, Texas
David R. Weichert	Century Electronics and Instruments 1133 N. Utica	Tulsa 10, Okla.
P. A. Weirich	Gulf Oil Corporation 600 Braniff Bldg.	Okla. City 2, Okla.
E. L. Wells	c/o Continental Oil Co.	Ponca City, Okla.
Edward H. Weltsch	4646 E. 55th St.	Tulsa 5, Okla.
Frederick H. Wessman	Box 3082	Durango, Colo.
G. H. Westby	Seismograph Service Corporation P. O. Box 1590	Tulsa 1, Okla.
James A. Westphal	Box 262	Owasso, Okla.
Alan White	c/o The Tulsa Tribune P. O. Box 1770	Tulsa 3, Okla.
Loren E. Whitehead	Drawer 1267	Ponca City, Okla.
Robert L. Wilcox	5336 E. 30th St.	Tulsa 14, Okla.
Stanley W. Wilcox	Box 1590	Tulsa, Okla.
Bruce F. Wiley	912 Shawnee Ave.	Bartlesville, Okla.

P. S. Williams	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Billy F. Wilson	512 Wilmington	Bellaire, Texas
Riley Wilson	Tulsa World 315 S. Boulder	Tulsa 3, Okla.
J. R. Winnek	Dayton Exploration Company 5730 E. Admiral Pl.	Tulsa 15, Okla.
Herman Wirz, Jr.	Jersey Production Research Company 1133 N. Lewis Ave.	Tulsa 10, Okla.
Phillip W. Wise	Sinclair Research Labs., Inc. Box 3006, Whittier Sta.	Tulsa 8, Okla.
Richard A. Wise	Sunray Mid-Continent Oil Company Box 2039	Tulsa 2, Okla.
R. O. Whitaker	Skelly Oil Company Skelly Bldg.	Tulsa 19, Okla.
L. A. Woker	P. O. Box 2420	Tulsa 2, Okla.
Earl M. Wolters	Phillips Petroleum Company 416 Bank Bldg.	Bartlesville, Okla.
James T. Woodburn	Century Geophysical Company 515 S. Main	Tulsa 3, Okla.
J. H. Yelken	Phillips Petroleum Company 200 Koppel Bldg.	Bartlesville, Okla.
Dr. H. M. Zenor	Missouri School of Mines Geology Department	Rolla, Mo.
Raymond C. Zongker	Ideal Specialty Co. 2531 E. Independence	Tulsa 10, Okla.
William J. Zwart	Box 2040	Tulsa, Okla.



WE COVER THE WORLD TO HELP YOU FIND OIL



Exploration in 55 foreign countries and in the United States for 30 years has given SSC crews experience in almost every conceivable type of environment. From small, one-crew jobs to large surveys using many crews, SSC has continually provided effective results at reasonable costs.

At your disposal, SSC has a wide range of specialized equipment designed to produce results anywhere in the world.

Call on SSC's experience for your geophysical surveys, anywhere in the free world.

Seismograph Service Corporation

P. O. Box 1590 • TULSA, OKLAHOMA • NAtional 7-3330

WORLD-WIDE SUBSIDIARIES

SSC of Argentina • SSC of Bolivia • SSC of Canada • SSC of Colombia • SSC International • SSC of Libya • SSC of Mexico
Seismograph Service Limited — England
Seismograph Service de España, S. A.
Compagnie Française de Prospection Sismique

Seismic Engineering COMPANY

ENGINEERED SEISMIC SURVEYS

6111 MAPLE AVENUE • DALLAS • TEXAS
R. D. Arnett C. G. McBurney J. H. Pernell